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ABSTRACT

This document was designed to assist teachers who are helping ninth grade students in New York City learn scientific concepts. In addition, the guide emphasizes basic reasoning skills which underlie problem-solving processes in scientific and nonscientific disciplines. The first section of the guide contains lessons on what a scientist does, measurement, and scientific reasoning. The second section provides the teacher with activities on basic energy concepts including heat energy, light, sound, electricity, and current and future energy resources. At the end of each unit is a list of review questions, and a final examination is provided for each of the two major sections. Also included is a bibliography for students, a list of government sources for further information, selected teacher references, a list of film strips and an evaluation form to be used by the teacher to judge the effectiveness of the materials. (TW)

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# GENERAL SCIENCE

Experimental

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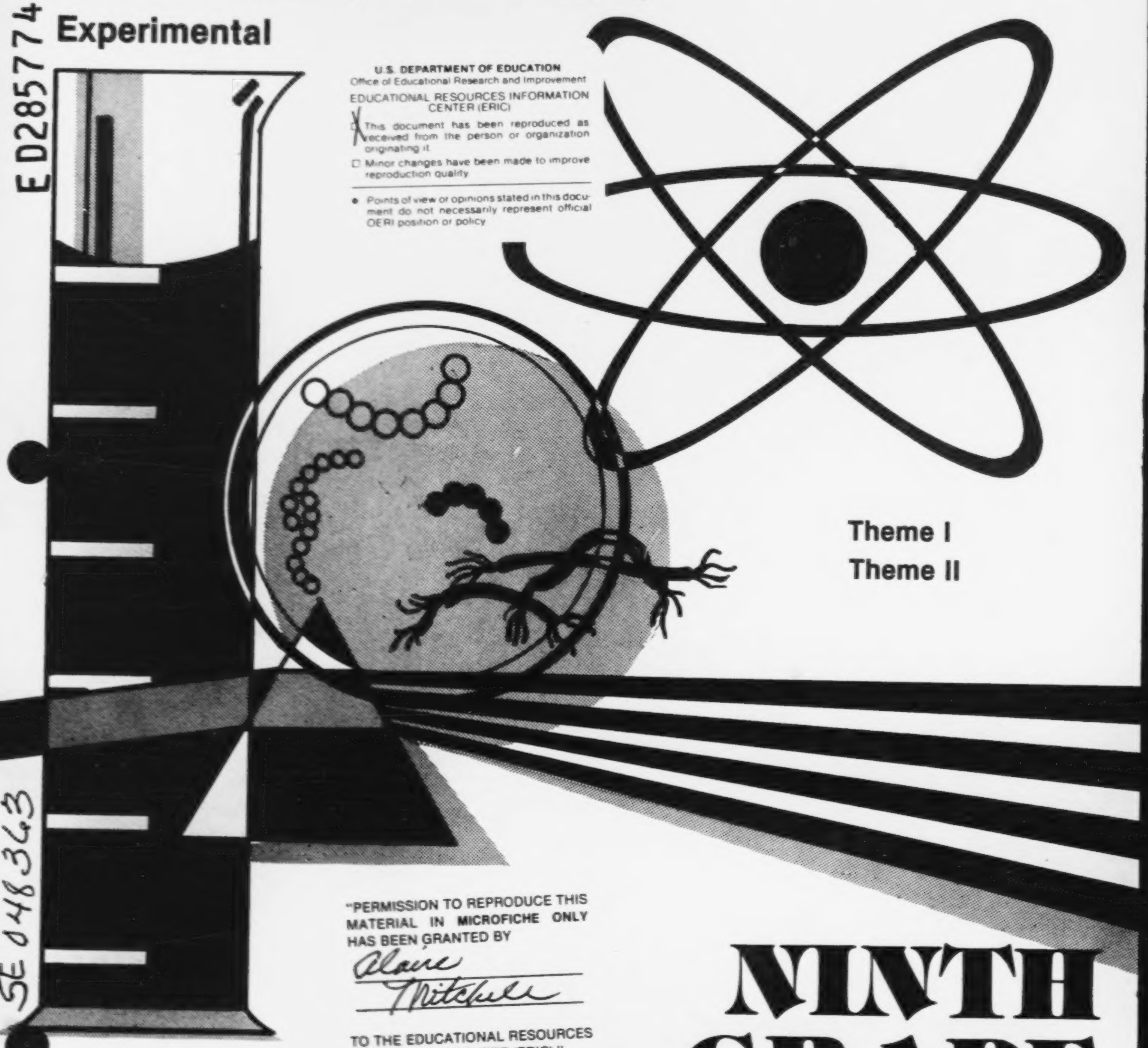

Theme I
Theme II

SE 048363

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# NINTH GRADE

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# FOREWORD

In our technologically oriented society, students need to acquire scientific literacy. To meet this goal, Ninth Grade General Science has been designed to help New York City students learn about the scientific process as well as basic science concepts. In addition, the curriculum emphasizes basic reasoning skills which underlie problem-solving processes in scientific and nonscientific disciplines. In the lessons in this guide, students are encouraged to:

- make hypotheses
- plan, design, and implement investigations
- collect, plot, chart, and interpret data
- explore in depth topics of common concern, such as placement of nuclear power plants
- make decisions based on evidence rather than supposition or emotion
- discuss careers that are related to the scientific enterprise
- understand the need for controlled experiments
- recognize the need to modify hypotheses on the basis of new evidence

The lessons in this guide have been prepared as models for the inexperienced teacher and as points of departure for the experienced teacher. It is not our aim that all teachers in all classes teach the material the same way, or even in the same sequence. These lesson guides represent a synthesis of several points of view, and represent one way in which the objectives of the general science curriculum can be implemented. For example, teachers will think of motivations which are more suited to their own classes and teaching styles and they will develop concepts different from the models in this guide.

We request that all teachers who teach Ninth Grade General Science complete the questionnaire included at the back of each guide and return it to the Science Unit as soon as they finish teaching the course.

We hope this guide will serve to stimulate teachers to think more about general science and its role in helping students to develop scientific literacy.

Charlotte Frank

Charlotte Frank
Executive Director
Division of Curriculum and Instruction

# ACKNOWLEDGMENTS

The present adaptation of the ninth grade course of study in general science is the outgrowth of several years of work by many individuals. It is a project of the Division of Curriculum and Instruction, Charlotte Frank, Executive Director, and the Office of Curriculum Development and Support, Morris Freedman, Director. The curriculum was produced under the supervision of Anthony Galitsis, Director of Science.

Begun in 1979 by a group of science teachers and supervisors who wanted to delineate more precisely those skills and concepts that students should possess in order to be successful in high school biology, the first draft appeared as the experimental edition of the *Minimum Learning Essentials* in the Spring of 1981. Feedback from numerous individuals, analysis of student test results in January 1982, and comments from teachers who taught courses of study based directly upon the first draft, were analyzed with a view toward revising the *Minimum Learning Essentials* to provide a complete course of study that would at once both stimulate and absorb the urban ninth grade student. Throughout, the goals of the original writing committee were kept in mind.

In July 1982, a writing team consisting of Jordan Shein (Jamaica HS), Jane Weiss (Forest Hills HS), Mary DiBlasio (FDR HS), Audrey Saltsberg (JHS 218Q), Simon Fenster (Mable Dean Bacon HS), Harold Alper (South Shore HS), and Audrey Baden (Flushing HS, representing the Division of Special Education), met to plan the translation of the *Minimum Learning Essentials* into the program found in this present volume. Under the supervision and direction of Dr. Galitsis, the writers investigated the curricula of many cities and states throughout the United States. The end result was a decision to produce a course of study made up of four complementary themes, as opposed to a course of study based on the usual division of the course into the usual "four sciences," biology, chemistry, physics, and earth science.

The committee felt that science today is best approached through a "unified" approach: the melding of all the sciences in an attempt to understand those problems that occupy the minds of most scientifically literate citizens today: namely energy, disease, and the environment. By September 1982 the first half of the new course of study was ready for trial in the schools. Albert Tarendash (Stuyvesant HS), reviewed and edited the trial manuscript in August of 1982. Volunteers were solicited to teach the lessons and comment on their merits. Sallejane Seif of the Division of Special Education provided assistance in locating teachers of special education to field-test the new curriculum. All together more than 50 teachers field-tested all or parts of the new course, and provided valuable feedback.

In the Spring of 1983, Eugene McCoy (Martin Luther King, Jr. HS) and John Bruno (High School of Music and Art) were asked to collate all of the feedback received from the teachers field-testing the curriculum. Their report was presented to the writing team, which now consisted of Joel Beller (Francis Lewis HS), Donald Abramson (Martin Van Buren HS), Audrey Saltsberg and Audrey Baden. John Kominski, Assistant Director of Science, supervised the writing team during the writing of the last half of the curriculum. The committee decided to call together teachers who were field-testing the curriculum to make specific suggestions for revising the course. Two such meetings took place during May 1983, and the suggestions received from the participants formed the basis for the revision that was to follow.

During the summer of 1983, a revision committee consisting of Audrey Saltsberg, Michael Perlman (Jamaica HS), and Carol Izzo (Grover Cleveland HS) began work on the final draft of the curriculum, and finished it in August of that same summer.

Throughout the school year 1982-83, the material was reviewed and edited by Sidney Harris (John Bowne HS, retired) and Anthony Galitsis, who each introduced many "Notes to the Teacher" throughout the course guide to provide background information and helpful hints to the teacher.

Additional feedback and suggestions were received during the 1983-1984 school year. These suggestions were incorporated into this final revision in the spring of 1984 by Harold Friend (JHS 25Q) and Joel Beller (Francis Lewis HS).

Special lessons on decision making were contributed by Jay Kahn (JHS 234B) and Juliet Simms (Morris HS) and incorporated into the final revision.

The following teachers and supervisors, not mentioned above, deserve special mention for their willingness to travel into uncharted waters by field-testing and evaluating the curriculum in its formative stages. Without their feedback and determination to stick it out, even though they did not know what they would be teaching for more than four or five weeks at a time, it would not have been possible to present this course of study in its present form.

Teachers involved in pilot-testing Ninth Grade General Science curriculum and who returned completed evaluations forms are Maria Allan Capoti, Herbert H. Lehman HS; Harold Alper, South Shore HS; Audrey Badin, Flushing HS; Joel Beller, Francis Lewis HS; David Brown, Francis Lewis HS; John Bruno, Music and Art HS; T. Campo, John F. Kennedy HS; Joyce Chester, Martin Luther King, Jr., HS; Frank DeFelice, Jamaica HS; R. Effinger, Herbert H. Lehman HS; Steven Farbstein, Jamaica HS; Julia Garcia, Alfred E. Smith HS; Fred Isaacs, Alfred E. Smith HS; Clifford J. Jensen, Boys and Girls HS; Larry Kahn, Martin Van Buren HS; Andrea Kanner, Francis Lewis HS; Michele Kearse, Far Rockaway HS; Gerald Macmillian, Thomas Jefferson HS; Barry Malloy, Martin Luther King, Jr.

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The members of the feedback committee were Joyce Chester, David Brown, Audrey Saltsberg, Joel Beller, Andrea Kanner, Michael Perlman, Michele Wolf, John Bruno, Lucille Smith, Karren Izzo Karle, Jane Weiss. In addition, the help and cooperation of David Goldberg (Assistant Principal, JHS 296K) is gratefully acknowledged.

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The final manuscript was reviewed by Herbert Gottlieb (Martin Van Buren HS, retired) and was prepared for publication by the Curriculum Editorial and Production Unit, Alaire Mitchell, Unit Head. Peter Dews edited and supervised the production of the final manuscript. Steven Goodman and Judith Goldberg provided major editorial contributions. Maureen Maguire coordinated the printing and distribution. Artwork by Kathleen Asvestas and Tom Wright. Cover design by John Gampert.

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# INTRODUCTION

Science can be both enjoyable and practical, and the Ninth Grade General Science curriculum has been written with this thought in mind. The lessons emphasize hands-on learning experiences, scientific processes, and the social, political, and moral implications of scientific issues.

Hands-on learning activities such as laboratory experiments allow students to participate in the processes of science. In this edition of the Ninth Grade General Science curriculum, hands-on activities are part and parcel of the lesson -- not just adjuncts to motivate or culminate lessons.

While not all students can or will become scientists, our technological society demands that students become literate in the basic sciences. Some science curricula assume that students have mastered the processes of science; this curriculum deliberately trains students in processes such as making hypotheses, observing and recording data, and drawing conclusions based on that data.

Ninth grade students are beginning to think about careers. To help students clarify their own thinking, the Ninth Grade General Science curriculum includes information about careers in the sciences.

It may once have been possible to think that science and its products existed in a vacuum, but that is no longer true. Our society is increasingly faced with critical issues--such as pollution control, biomedical engineering, and energy production--that require not only solutions to technical problems but decisions about society's priorities. The Ninth Grade General Science curriculum includes lessons that pose political and ethical questions involving scientific issues.

## Content

The Ninth Grade General Science curriculum draws from a variety of scientific disciplines and includes lessons on a range of scientific topics from measurement to light to health. These lessons not only introduce topics that are of importance to an educated person in our society, but serve as the springboard for the processes that are the focus of this curriculum.

The curriculum is organized into four themes. In Theme I students learn about laboratory equipment and procedures, scientific method, and basic skills of measurement. In Theme II they investigate various forms of energy and examine energy conservation and alternative sources of energy. In Theme III, students focus on environmental science, examining the past and present environments of the earth, studying pollution and its effects, and predicting the environment of the future. In Theme IV, students study disease and its relationship to cause and effect and to the scientific method. They examine the prevention and control of disease, the factors influencing longevity, and implications for the future.

Within each theme, units include several lessons that focus on a specific topic. All lessons have the same organization:

a. Topic
b. Suggested Aim
c. Performance Objectives
d, Motivation
e. Development
f. Summary
g. Topics for Further Consideration (thought-provoking questions that can be used as a basis for homework.)

Many lessons include laboratory worksheets which are identical to those found in the student laboratory manual for this course.

PLEASE NOTE:

In the event that city-wide tests are developed for this course, the test items will be limited to Themes I, II, and III. Theme IV is considered to be an optional theme, and may be taught in part or in whole, or may be completely omitted by schools, depending on their particular circumstances. Teachers are encouraged to develop alternatives to Theme IV for use in their schools, and to share their lessons with the Science Unit.

We believe that by making Theme IV optional, we can provide schools with the flexibility to use the extra time in various ways: to spend more time on the difficult parts of the course; to teach more of the basic skills to students; or to develop lessons on topics of current interest such as astronomy, outdoor education, Halley's Comet, and so on.

## Implementation

We suggest that you read each unit in advance. As you plan the lessons for your own students, you will be able to draw on the suggested lessons, student worksheets, bibliography, and list of available audiovisual materials. Because there is yet no single textbook that parallels the topics in this curriculum exactly, you will need to select readings from a variety of sources based on the topics involved and the reading ability of your own students.

The following ideas may help you implement the curriculum more smoothly:

1. The first three weeks of the term involve a lot of laboratory work. Check the equipment available in your school against the materials suggested for use in the lab experiences.

2. To make sure you are familiar with the experiments and that students can do them safely, perform each demonstration and lab experience in advance.

3. Many of the lab experiences use equipment that is breakable and valuable. Discuss this with students as you talk with them about safety precautions and replacement procedures.

4. The ideal science classroom should have movable chairs and tables, running water, gas, and electrical outlets.

5. On one of the first days of class, organize students into lab groups of four students each. Give each group a number or name and assign a place in the classroom to work. Assign responsibilities to members of each lab group (captain -- picking up lab sheets and equipment, cleaning up, etc.) and set up a system to rotate the responsibilities.

6. For each lab experience there is a teacher's guide and a student worksheet. Reproduce additional copies of the student worksheet if they are needed. These may be completed for homework and brought to class for reading and discussion. It is a good idea to have the students maintain a looseleaf notebook or other binder in which marked lab sheets are permanently kept.

7. Have all students read the Introduction and Procedure sections of the worksheet before beginning each exercise. Be sure that students are clear about the purpose of the activity and that they understand the directions.

8. Putting the lab equipment on a tray such as a lunch tray or a similar tray will keep the equipment together and prevent liquids from spilling on the floor.

9. Use a variety of teaching methods with students and introduce study skills, such as directed reading, that will help students develop good study habits. Where appropriate, assign both reading and writing for homework so that students can develop their literacy skills.

10. Use the tests provided at the end of each unit or theme as another learning experience. Go over the students' answers, and find out why they missed certain items. This may lead you to reteach some points that caused difficulty.

11. In lessons where debates or panel discussions are called for, it is important that your views do not influence the students. Many of the issues presented in this syllabus have no answers acceptable to everyone. The important thing is to make sure that students understand the capabilities as well as the limitations of science. They must also realize that human values and politics often take precedence in making decisions dealing with science.

We hope you like this course of study. It represents the results of several years of work in which curricula from many cities and states were reviewed, and includes the most up-to-date thinking of science educators everywhere as to what science "should be."

We request that all teachers of Ninth Grade General Science complete the questionnaires included at the back of each of the two volumes of the guide and return them to the Science Unit, Division of Curriculum and Instruction, New York City Board of Education, 131 Livingston St., Brooklyn, NY 11201, as soon as they finish teaching the course.

# PERFORMANCE OBJECTIVES

Ninth Grade General Science is based on the philosophy that science teaching must incorporate the processes of science as well as the content. This imperative is reflected in the performance objectives outlined below.

This list of processes was adapted from those developed by the Science Bureau of the New York State Education Department for use in their syllabi for Grades 7-9. The mastery of these processes and the mastery of the science content are equally essential.

Each of the science process skills listed below is keyed to one or more of the content objectives which follow. For example, an objective such as "be able to utilize a data table and be able to draw conclusions from a graph" might be keyed to processes [12], [13], [14], and [15].

## Science Process Skills

[1] Observing objects and phenomena
[2] Describing observations
[3] Selecting suitable measuring instruments
[4] Developing skills in using laboratory equipment
[5] Measuring objects and phenomena with appropriate precision
[6] Performing laboratory techniques correctly
[7] Estimating and measuring within limits of accuracy
[8] Recognizing a problem
[9] Formulating a working hypothesis
[10] Selecting appropriate tests to prove or disprove a hypothesis
[11] Designing suitable procedures for experimental tests
[12] Processing experimental data
[13] Organizing data to show a functional relationship
[14] Interpreting observations and data
[15] Interpolating and extrapolating
[16] Evaluating a hypothesis in the light of data obtained
[17] Formulating generalizations based on relationships
[18] Recognizing the need for a theoretical model
[19] Formulating a theoretical model to accommodate knowledge
[20] Designing relationships satisfied by a model
[21] Deducing a hypothesis from a theoretical model
[22] Interpreting and evaluating tests of a model
[23] Producing a revised, refined, or extended model

Numbers in brackets, [ ], following each objective are keyed to the Process Skills listed on the preceding page.

## THEME I: Laying the Groundwork

### Unit 1: What a Scientist Does

The students will be able to:

- Identify equipment found in the laboratory. (Acquaintance with the following pieces of equipment is essential and students will be tested on them: triple beam balance, graduated cylinder, meterstick, alcohol lamp, Bunsen burner, beakers, flasks, test tubes, test tube holder, test tube rack, ring stand, wire gauze, medicine dropper.) [1], [4], [6]

- Recognize the need for proper handling and use of equipment. [1], [4], [6]

- Observe the following essential student safety rules:

  a. Report all accidents or injuries to your teacher at once.

  b. If any substance spills on you or gets into your eyes, wash with water and notify your teacher at once.

  c. Do not perform experiments that are unauthorized. FOLLOW DIRECTIONS.

  d. If any glassware breaks, inform your teacher at once. DO NOT TOUCH THE BROKEN GLASS.

  e. Never handle apparatus or chemicals in the laboratory until you have received instructions in its proper use.

  f. Wear sensible clothing that cannot come in contact with science apparatus or chemicals.

  g. Do not transport dangerous chemicals.

  h. Do not taste chemicals or other unknown materials.

  i. Be aware of all safety instructions for each laboratory activity that presents a hazard.

  j. You may not use propane burners in laboratory experiments.

  k. Never pour reagents back into their original containers.

  l. Never touch any electrical device which has just been used.

m. Handle steel wool carefully to avoid getting any fragments into your skin. When possible, use tongs.

n. When working with an alcohol lamp, use a nonflammable surface, well away from the edge of the table. Check to see that spilled alcohol is wiped before the lamp is ignited. Take all precautions to make certain that the lamp does not tilt or leak. (Students should never be allowed to fill alcohol lamps.)

o. Never touch any hot materials with your hands.

p. Always direct the mouth of a test tube being heated away from yourself and from others.

q. Never look directly at the sun. Instead, project the image of the sun on a wall screen.

r. Exercise caution when doing work at home in connection with projects or science fairs. For example, dangerous chemicals that should be avoided or used only under direct supervision of a qualified adult include hormones, carcinogens, radioactive isotopes, and explosives.

s. Do not use thermometers as stirring rods. Do not collect mercury from broken thermometers.

t. Never engage in horseplay in the science classroom.

## Unit 2: Dimensions

The students will be able to:

- Read the scale on a metric ruler to within 0.1 cm (1 mm). [3], [4], [5], [6], [15]
- Estimate the measurements when the observed length of an object falls between two of the unit lines. [3], [4], [5], [6]
- Recognize that the numbered units on a metric ruler are called centimeters (cm) and that each of these is divided into ten smaller units called millimeters (mm). Convert cm into mm or the reverse by moving a decimal point. [3], [4], [5], [6]
- Define volume as an amount of space which can be occupied by a substance. [1], [2]
- Observe that water sticks to the sides of a pyrex graduated cylinder producing an upward curve of water against the sides of the cylinder and a downward curve in the center (meniscus). [1], [2], [4], [5]
- Define the meniscus as the curve that water forms in a cylinder. [6], [7]
- Read the volume of the water from the bottom of the meniscus to the nearest .2 ml. [6], [7]

- Equate 1,000 ml to one liter. [3], [5], [6]

- Read in gram units the metric scale on the three beams of a balance. [3], [5], [6] [7], [12]

- Determine masses of objects to within 0.1 g. [3], [5], [7], [12], [15]

### Unit 3: Scientific Reasoning

The students will be able to:

- List the steps in the scientific method. (The objective of science is to formulate valid and reliable theorems and laws.) [1], [2], [8], [9], [10], [11], [12]

- Use observations to ask questions. [1], [2]

  a. Apply information learned in an experiment to explain new situations.

  b. Identify the control in an experiment.

- Read the scales on a Celsius thermometer by applying the principles learned when using the metric ruler, the graduated cylinder, and the triple beam balance. [1], [2], [3], [4], [5], [6], [7]

## THEME II: Power Sources and Resources

### Unit 1: It's all Elementary (Chemistry)

The students will be able to:

- Define matter as anything that has weight and takes up space. [2]

- Identify the states of matter as solid, liquid, or gas. [2], [9], [16]

- Define an element as a substance which cannot be ordinarily taken apart to produce two or more different substances. [1], [2]

- Define a compound as being made of two or more elements chemically combined in a definite proportion. [2], [6], [11], [17]

- State that a compound differs in properties from the elements of which it is made. [2], [6], [17]

- Differentiate among elements, compounds, and mixtures. [2], [6], [11], [17]

- Recognize that elements are made up of very small particles called atoms. [2], [18], [19], [20]

- Recognize that atoms are made up of sub-atomic particles called electrons, protons, and neutrons. [18], [19], [20]

- Compare the mass and charge of protons, neutrons, and electrons. [2], [17]
- Use a Periodic Table to compute the number of electrons, protons, and neutrons in a specific atom. [12], [14]
- Define atomic number as the number of protons in the nucleus and define atomic weight as the total weight of the protons and neutrons in the nucleus. [2], [17]
- Define a formula as a shorthand method of showing the kinds and numbers of atoms in a substance. [2], [17]
- Relate chemical energy to heat and light energy. [19], [20]
- * Relate the properties of atoms to the number of electrons and electron shells. [18], [19], [20], [22]
- Relate compound formation to changes in chemical energy. [2], [17]
- * Relate the chemistry of carbon atoms to the chemistry of life. [2], [17]
- State the law of conservation of matter and relate it to the law of conservation of energy. [2], [6], [9], [10], [11], [17]

-- -- -- -- -- -- -- -- -- -- -- --

* Objectives preceeded by an asterisk (*) are optional and are not subject to examination.

Unit 2: Heat on Earth

The students will be able to:

- State that heat energy can be transferred from one area to another by convection, conduction, and radiation. [2], [8]
- Relate heat to the kinetic molecular theory. [8], [9], [10], [11]
- Use a calorimeter to measure heat. [3], [4], [7]
- Apply the principles of heat transfer to methods of preventing heat loss. [9], [10], [17]
- Recognize that different materials transfer heat at different rates. [9], [10], [17]
- State that heat flow can be slowed down by use of insulating materials. [2], [8], [11], [12]
- List various types of insulating materials. [2]

- Distinguish between heat and temperature. [8], [17]

- Relate heat expansion of matter to an increase in the velocity of molecules. [2], [17]

- Apply knowledge of the characteristics of heat energy to the design of home heating systems. [2], [19], [22]

Unit 3: I See the Light

The students will be able to:

- Identify light as a form of energy. [2]

- Interpret the spectrum to show that white light is made up of colors. [2], [9], [10]

- * Construct a telescope from two convex lenses and describe how it works. [10], [11], [12]

- Describe how convex and concave lenses focus light. [2], [6], [10]

- * Compare the characteristics of a mirror to the characteristics of a lens. [2], [6]

- Discover the properties of plane, convex, and concave mirrors and apply these properties to a variety of commonly used items. [2], [6], [17]

- Relate the structure of the human eye to its function. [2], [11], [17]

- Identify the parts of the electromagnetic spectrum (invisible light). [1], [2], [6]

Unit 4: A Sound Reason

- Explain the causes of sound. [2], [17]

- Trace the transmittal of sound. [2], [13].

- Detail the characteristics of sound waves. [2], [14], [17]

- Describe how the human ear detects sound. [2], [13]

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* Objectives preceeded by an asterisk (*) are optional and will not be subject to city-wide examinations.

## Unit 5: A 'Current' Topic

The students will be able to:

. Explain how objects can be electrically charged. [2]

. Demonstrate that a flow of electrons can do work. [1], [2], [11], [12]

. Illustrate the behavior of electrically charged bodies. [1], [2], [11], [12]

. Describe how lightning is formed. [2]

. Discuss the beneficial and harmful effects of lightning. [17]

. Describe how we can protect ourselves from lightning. [17]

. * Identify electricity as a form of energy. [1], [2], [6]

. * Describe characteristics associated with flowing electrons. [1], [2], [6], [10], [11]

. * Compare and contrast a variety of factors that influence the flow of electrons. [1], [2], [3]

. * Describe some factors that influence the resistance of a wire. [2], [11], [12]

. Relate power to electrical usage. [11], [12], [13], [14]

. Become wiser consumers of electricity. [2], [17]

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* Objectives preceeded by an asterisk (*) are optional and will not be subject to city-wide examinations.

## Unit 6: Insuring Our Energy Future

The students will be able to:

. Define the term nonrenewable as related to fossil fuels. [2], [17]

. Trace the formation of fossil fuels. [2], [17]

. Justify the need to conserve energy. [19], [20]

. Relate the roles of government, industry and consumers in conserving energy. [2], [17]

. Describe various techniques available to expand our supply of energy including use of renewable sources. [2], [19], [20], 23]

. Explain why some atoms are radioactive. [2], [17]

. Relate half-life to the rate of radioactive decay. [2], [12], [13], [14], [15]

. Contrast nuclear fusion and nuclear fission reactions. [2], [17]

. Recognize that the energy produced in a nuclear fission reactor can be converted to electricity. [2], [17], [18], [19], [20]

. State how a nuclear reaction may take place in a controlled way. [2], [17]

. * Describe how a nuclear reactor works. [2], [17]

# SAMPLE CALENDAR

This calendar is an example of how the Ninth Grade General Science course of study may be approached. Depending upon the nature of the students, this guideline will not be strictly applicable to every school.

1984-1985

| | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|---|
| Sept. | | | | Sept. 13<br>Theme I<br>Unit 1<br>Lesson 1 | 14<br>Lesson 2 |
| | 17<br>Lesson 3 | 18<br>Lesson 4 | 19<br>Lesson 5 | 20<br>Review or Quiz | 21<br>Unit 2<br>Lesson 1 |
| | 24<br>Lesson 2 | 25<br>Lesson 3 | 26<br>Lesson 4 | 27<br>Lesson 5 | 28<br>Lesson 6 |
| Oct. | 1<br>Lesson 7 | 2<br>Lesson 8 | 3<br>Lesson 9 | 4<br>Review | 5<br>Quiz |
| | 8<br>Unit 3<br>Quiz or Pretest | 9<br>Lesson 1 | 10<br>Lesson 2 | 11<br>Lesson 3 | 12<br>Lesson 4 |

# MATERIALS TO BE USED IN THEME I

ALCOHOL BURNERS
APRONS
BALANCE, TRIPLE BEAM
BATTERY JAR
BEAKERS
BEAKERS, 250 ML
BEAKERS WITH GRADUATIONS
BEANS
BUNSEN BURNER
BURETTES
COPPER NITRATE
CUBE, 1 LITER, DISSECTIBLE
CUBES FOR MEASURING PRACTICE
DROPPER, MEDICINE
FACE SHIELD
FLASK, FLORENCE
FUNNELS
GLOVES
GRADUATED BEAKER, 1 LITER
GRADUATED CYLINDER
GRADUATED CYLINDER, 1 LITER
HOT PLATE
HYDROCHLORIC ACID
METER STICKS
METRIC TAPE MEASURE
PANS FOR WATER
PAPER TOWELING
PICTURES, CELLS
PICTURES, FOSSILS
PICTURES, STARS
PICTURES, TELESCOPES
PICTURES, VIRUSES
PIPETTES
PLANTS, BEAN
PLASTIC FOOD WRAP
RUBBER TUBING
RULERS, METRIC
SAFETY GLASSES
SCISSORS
SODIUM
SODIUM HYDROXIDE
TEST TUBE HOLDERS
TEST TUBE RACKS
TEST TUBES
THERMOMETER, FEVER
THERMOMETER, INDOOR-OUTDOOR
THERMOMETER, OVEN
THERMOMETERS, FAHRENHEIT/CELSIUS
TONGS
TRIPODS
VEGETABLE COLORING
WATER CONSENSER
WEIGHT SETS
WEIGHTS, STANDARD
WIRE GAUZE

# MATERIALS TO BE USED IN THEME II

ALLIGATOR CLIPS
ALUMINUM FOIL
BALL AND RING APPARATUS
BALLOONS
BEADS IN MERCURY TUBE
BEAKER, 1000 ML
BEAKER, 25 ML
BELL IN BATTERY JAR
BIMETALIC STRIP
BROMINE
BULB, 40 WATT
BULB, 60 WATT
BULB 100 WATT
BUNSEN BURNER
CALCIUM
CALENDAR
CALORIMETER, TIN CAN
CAMERA
CANDLES
CARBON
CARBON, ATOMIC MODEL
CARDS, INDEX
CHART, ELECTROMAGNETIC SPECTRUM
CHART, EYE
CLAMPS
COAL, SAMPLES
CONSTRUCTION PAPER
COPPER
CUPS, STYROFOAM
DAPHNIA
DOWEL STICKS, WOODEN
DRY CELL, 1.5 VOLT
ELECTRIC METER FACE, MODEL OR TRANSPARENCY
EYE, MODEL, TAKE APART
EYEGLASSES
FLASHCUBE
FLASHLIGHT
FLASHLIGHT BULB IN SOCKET
FLASK, ERLENMEYER
FORCEPS

FOSSILS, SAMPLES
FUR
GEIGER COUNTER
GLASS PLATE
GLASS TUBING
GRAPHPAPER
HAMMER
HEAT CONDUCTIVITY WHEEL
HOFFMAN APPARATUS
ICE BUCKET, INSULATED
IODINE
IRON
IRON, PURE
IRON FILINGS
LAMP, DESK
LENS, CONCAVE
LENS, CONVEX
LENS, 15 CM FOCAL LENGTH
LENS, 30 CM FOCAL LENGTH
LENS HOLDERS
LITHIUM
LUCITE ROD
MAGNESIUM
MAGNETS
METAL ROD, LONG
METER STICKS
MICROPROJECTOR
MINERALS, FLUORESCENT
MIRROR, PARABOLIC
MIRROR, PLANE
NAILS, RUSTY
NICHROME WIRE, NO. 22 & 28
OPTICAL BENCH
PAPER CLIPS
PEAT MOSS
PERIODIC CHART
PERIODIC TABLES FOR STUDENTS
PETRI DISHES
PHOSPHORUS
PHOTOGRAPH, X-RAY
PICTURE, COLORBLIND TEST
PING PONG BALLS
PITH BALLS
PLASTIC ROD
POTASSIUM
PRISM
PROJECTOR, OVERHEAD
PROJECTOR, SLIDE OR MOVIE
RADIOACTIVE SOURCES
RADIOMETER
RING STANDS
ROCKS, IMPERMEABLE SAMPLES
ROCKS, PERMEABLE SAMPLES
ROPE, 30 FEET LONG
RUBBER BANDS
RUBBER ROD
RUBBER SHEET
RUBBER STOPPERS
RULERS, TRANSPARENT
SCALPELS
SCISSORS
SCREEN HOLDERS
SHOE BOXES
SILK
SLINKY®
SODIUM
SPOON, METAL
SPRINGS, LONG COILED
STEEL WOOL
STIRRING ROD
STOECKLE'S TUBE
STOPPER, ONE HOLE
STRING
SULFUR
SWITCHES
THERMOS BOTTLE
TOWELS, PAPER
TUNING FORKS
ULTRAVIOLET LIGHT SOURCE
VACUUM PUMP
WAX
WET CELL
WHISTLE, HIGH PITCH
WIMSHURST GENERATOR
WIRE, COPPER
WIRE, HOOKUP
WIRE, INSULATED BELL
WOOD SPLINTS
ZINC

# HAZARDS AND PRECAUTIONS

## Alcohol lamp

Use on a nonflammable surface, well away from the edge of the table. Make sure that the cap is not so tight that pupils cannot readily remove it. Check to see that any spilled alcohol is wiped up before the lamp is ignited. Make certain that the lamp does not tilt or leak. In no case are alcohol lamps to be filled by students. It is best that the lamps be filled the day before use, so that fumes are not present in the room. If filled the same day, wipe off all liquid from the outside of the lamp.

IN NO CASE SHOULD THE SUPPLY OF ALCOHOL BE PRESENT IN THE ROOM AT THE SAME TIME THE LAMPS ARE BEING USED.

## Eyes

Protect the eyes with goggles or face shields when heating substances, especially when there is danger of splattering. Do not rub the eyes after handling materials. Instruct pupils to direct the mouth of a test tube being heated away from themselves and others. Caution pupils never to look directly into the sun, but to project the image on a wall or screen. Use special goggles when working with ultraviolet light or when viewing a carbon-arc source.

## Asbestos

Wire gauze with asbestos centers, as well as asbestos pads, should be discarded according to the instructions on page 2 of Science Safety, K - 12. Suitable replacements for asbestos-containing materials may be found in catalogs of scientific supply houses, as well as in the New York City Board of Education Bureau of Supplies Catalog.

## Science Safety Manual

Additional safety procedures and precautions may be found in the New York City Board of Education publication, Science Safety: K - 12. A copy of this manual should be available in the office of the assistant principal in charge of science. Additional copies may be purchased from the Bureau of Supplies or the Publication Sales Store, Room 136, 110 Livingston St., Brooklyn, NY 11201. This safety manual should be read thoroughly by all instructors before teaching Ninth Grade General Science.

# THEME I

# LAYING THE GROUNDWORK

# UNIT I. WHAT A SCIENTIST DOES

## Lesson 1: THE WORK DONE BY SCIENTISTS

AIM: "What do scientists do?"

PERFORMANCE OBJECTIVES: The students will be able to:

. list three things that scientists do.
. contrast a scientific theory and a scientific law.

MATERIALS: Examples or pictures of fossils, telescopic photographs, photographs of stars, photographs of cells or tissues taken through the microscope, electron micrographs of viruses, tongs, beaker of water, safety glasses, gloves, face shield, apron, sodium under oil.

CAUTION: Sodium is a dangerous corrosive metal and should never be exposed to heat or an open flame. It reacts violently with water. It is stored under oil to prevent contact with moist air. When handling it, be sure to use the safety equipment. Be sure that the tongs are DRY. Some chemical supply companies sell a sodium-lead alloy that is 8% sodium. This is much safer to use than pure sodium. The reaction will be evident but not as violent as with the pure metal.

MOTIVATION: "No matter what branch of science a scientist specializes in, all scientists have some things in common. In this class, pretend that you are all scientists. What kinds of activities and jobs would you be doing?"

DEVELOPMENT

1. Scientists perform experiments and make discoveries.
    a. Scientists like Pasteur and Gabin search for the causes and cures for diseases.
    b. Scientists determine physical laws. Albert Michelson determined the speed of light. He used two mountains in California, a light source, an eight-sided mirror, and a telescope in his experiment.
    c. Scientists analyze matter. H. Davy discovered sodium by passing electricity through ashes from marsh grass (soda ash) in 1807. Show class sodium. Using precautions above, drop a small sodium pellet the size of a pea or less in water and observe. Make sure to use a large beaker half filled with water.
2. Scientists make observations.
    a. They observe stars and planets. (Show pictures.)
    b. They observe with the microscope. (Show micrographs.)
    c. They observe the properties of new synthetic materials like plastic.

3. Scientists repeat and confirm the experiments of other scientists.

4. Ask: "Why do scientists do these things?"

    a. To learn about the universe, chemical elements, plants and animals, etc.
    b. To help people live better and healthier lives.
    c. To form theories. A theory is an explanation of a phenomenon based on observations and experimentation and which is subject to change. Display fossils and discuss evolution as a theory in light of this definition.
    d. To establish laws. A law is a theory that has been tested over and over again and doesn't change. The law of conservation of energy is a good example.
    e. To make predictions such as the return of Halley's comet.

## SUMMARY

1. "Why is repeating another scientist's experiment important?"

2. "What is the difference between science and technology?"

3. "Why should scientists from all countries share the results of their experiments and observations?"

## FOR FURTHER THOUGHT

1. "What is the difference between a theory, a law, and a principle?"

2. "How does an inference differ from a prediction?"

3. "How does an inference differ from an observation?"

## Lesson 2: THE IMPORTANCE OF DIRECTIONS TO SCIENTIFIC METHODOLOGY

AIM: "How important are clear directions?"

PERFORMANCE OBJECTIVES: The students will be able to:

. solve a mathematical problem.
. explain the importance of an overview of a set of instructions.
. describe the importance of clear directions.

MATERIALS: Laboratory Worksheet 1.1, a piece of blank paper measuring 22 cm by 28 cm, scissors, ruler.

MOTIVATION: "How does the maxim, 'When all else fails, follow directions,' relate to the work of a scientist?"

DEVELOPMENT

1. Demonstrate the importance of directions in solving a math problem. Have students take out a piece of scrap paper and follow these directions. Then ask: "Why do we need to follow these directions carefully in order for us all to arrive at the same conclusions?"

   a. "Pick a number from 1 to 20. Write it down."
   b. "Double that number and write it down."
   c. "Add two to the doubled number and write it down."
   d. "Divide this number by two and write it down."
   e. "Subtract the original number and write down your answer."
   f. "What is your answer?" (All students will have reached the same answer -- one.)

2. Tell the class they will be given directions to make a paper model. The directions are deliberately confusing in order to impress upon the class the importance of clear directions and the necessity of obtaining an overview of directions before beginning a project.

3. Distribute Worksheet 1.1 and other materials.

4. Tell the students to follow the directions.

5. Ask the class to explain why it is so difficult to make the model. "Why are good directions important?"

# LABORATORY WORKSHEET 1.1

NAME ______________________________ CLASS ______________ DATE ______________

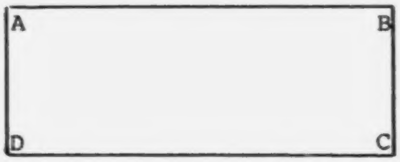
PROBLEM: Why is it difficult to perform a complicated task even though detailed written directions are supplied?

MATERIALS: A piece of blank paper measuring 22 cm by 28 cm., scissors, ruler.

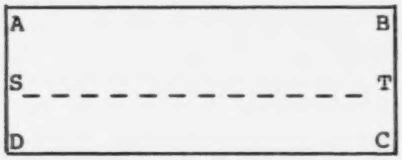
INTRODUCTION: When a scientist verifies (checks the accuracy) of a fellow scientist's experiment, much depends upon his ability to read and follow directions. Let's see how well you can follow the directions that are on this sheet.

PROCEDURE

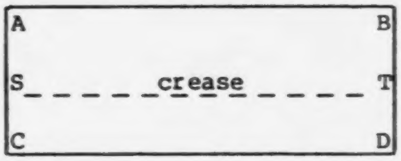
1. Cut out a rectangular piece of paper measuring 12 cm by 24 cm. Discard the scraps.
2. Label the four corners as shown.



3. Fold the paper in half, the long way. Crease it. Spread the paper out and write "S" and "T" on the middle crease.



4. Fold AB to ST and crease. Fold CD to ST and cease line. Press down and turn your model over.

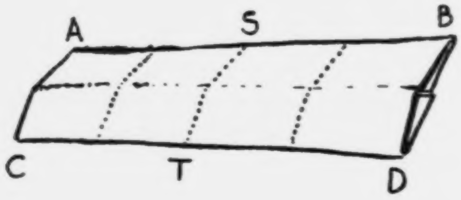


## LABORATORY WORKSHEET 1.1 (continued)

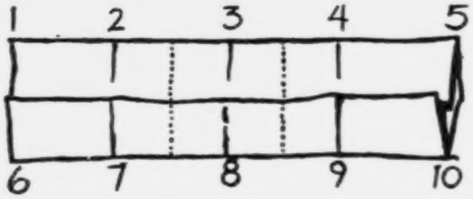
NAME ________________________________

5. Fold AC to BD. Now fold to ST. Crease and unfold what you have done. Fold BD to ST and Crease. Unfold your work and turn the model over.

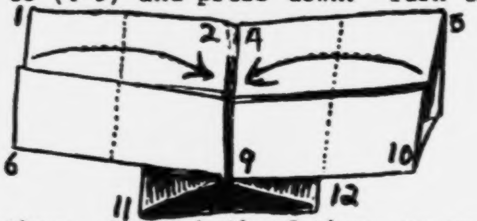
6. Mark your model as follows.



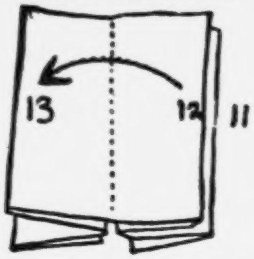
7. Fold (2-7) to (3-8) at the dotted line. Leave (1-6) alone. Fold (4-9) to (3-8) without changing (5-10). Press down.



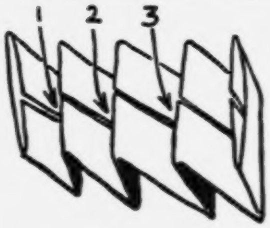
8. Add points 11 and 12. Fold (1-6) to (2-7) at the dotted line. Press down. Fold (5-10) to (4-9) and press down. Turn the model over.

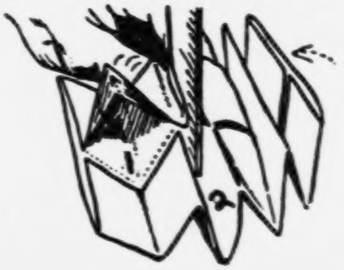


9. Fold 11 and 12 together. Press both of them, as one piece, to point 13 [add 13, if necessary]. Stand the model up.



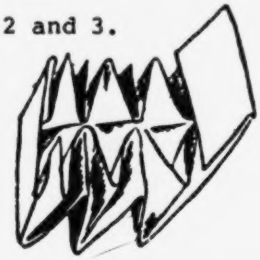
10. At the points 1, 2, and 3, lift the flaps at the bottom and pleat using the ruler.





# LABORATORY WORKSHEET 1.1 (continued)

11. Repeat with the flaps opposite to 1, 2 and 3.



12. Press, and fold as shown above. Lift up the end piece to form a flap.

    You have just made a MISER'S PURSE. This purse makes your dollars go a long way when you open it!

SUMMARY/HOMEWORK

1. What difficulties did you experience in making the MISER'S PURSE?

2. Did these directions help you to make the model?

3. Would following these directions more closely have helped you make the model? Why?

4. Which is more important in following directions, speed or accuracy? Justify your answer.

5. How is following directions on a lab sheet similar to reading an assignment in your textbook?

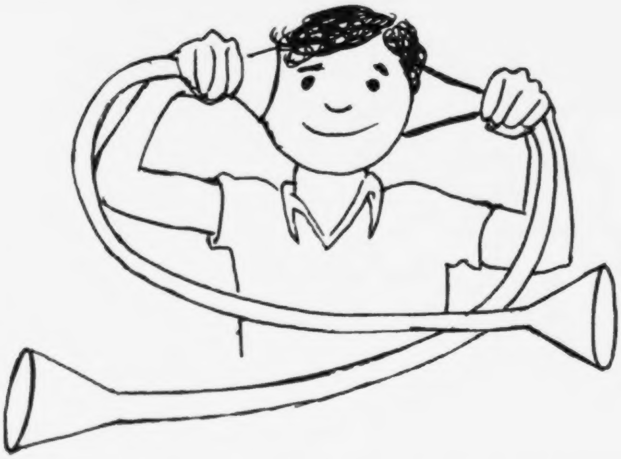
# Lesson 3: MAKING OBSERVATIONS

AIM: "How accurate are your senses?"

PERFORMANCE OBJECTIVES: The students will be able to:

. demonstrate the fallibility of their senses of sight, touch, and hearing.
. recognize the need for scientists to use instruments to make observations.

MATERIALS: Laboratory Worksheet 1.2, 1 pan of hot water, 1 pan of cold tap water, 1 pan of ice water, blindfold, homemade listening device (see diagram below), poster (see Motivation).



MOTIVATION: Prepare one of the posters illustrated below before class begins.

NOW
IS THE
THE TIME

PARIS
IN THE
THE SPRING

Keep the poster face down. Warn the class that they will have a short time to see the message on the poster. Show the message briefly. Then ask the class to write down what they saw. Send a few students to the board to write what they saw. Ask: "How can we explain any differences between what we saw and what we wrote down?"

## DEVELOPMENT

### I. Optical Illusions

1. Discuss optical illusions in the light of making observations. Then distribute Laboratory Worksheet 1.2 and have students complete this independently.

### II. Sense of Touch

1. Have a blindfolded volunteer simultaneously immerse one hand in a pan of warm water and the other hand in ice water for 15 seconds. Ask for the student's temperature sensations in each case.
2. Have the student remove both hands and place them in the pan of cold tap water, one at a time. Again, ask for sensations to be expressed to the class. (The cold hand will produce a sensation of warmth, but the other hand will give a contradictory sensation.)
3. Tell the class the temperatures of the water in each pan. Ask for conclusions that can be drawn from the experimental data.
4. Summarize the observations and conclusion(s) on the chalkboard.

### III. Sense of Hearing

1. Blindfold a volunteer standing in the center of the room.
2. Put the special listening device on the volunteer.
3. Arrange the funnels so that the one going to the left ear is on the right side of the volunteer's head. The other funnel over the opposite ear.
4. Have students in various parts of the room call to the volunteer. Ask the volunteer to tell where the speakers are seated. Record the accuracy on the board.
5. Repeat, but this time have the funnels arranged so that they are not going to the "wrong" ears.
6. "What conclusions can you draw from this experiment?"

## SUMMARY

1. "Why do scientists rely on thermometers, microscopes, telescopes and electrical meters rather than on their senses alone?"
2. "What measuring devices (other than those mentioned in the question above) do scientists use?"

# LABORATORY WORKSHEET 1.2

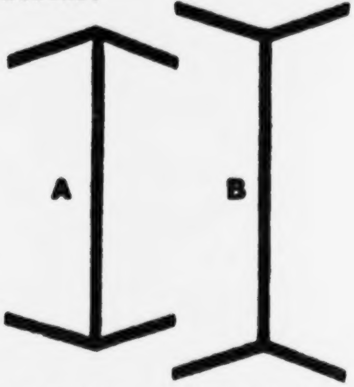
NAME ______________________ CLASS ____________ DATE ____________

PROBLEM: How accurate is my sense of sight?

MATERIALS: Metric ruler

INTRODUCTION: If you didn't have enough time to see the extra "THE" on the poster your teacher showed you, you will have additional chances to prove how well you see. The important thing is to discover if your eyesight is accurate and can be trusted to make observations.

PROCEDURE

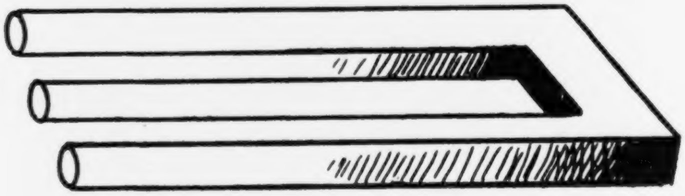


1. Look at vertical lines A and B. Which is longer? __________

   Use the ruler and check your answer. Which line does the ruler tell you is the longer? __________

2. What is wrong with the center rod in this picture? ______________________

   ____________________________________________________________



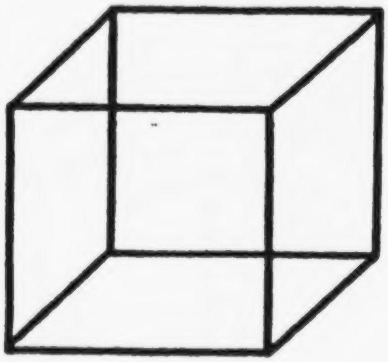
## LABORATORY WORKSHEET 1.2 (continued)

NAME ______________________________

Why is it impossible to make this out of wood in your school shop?

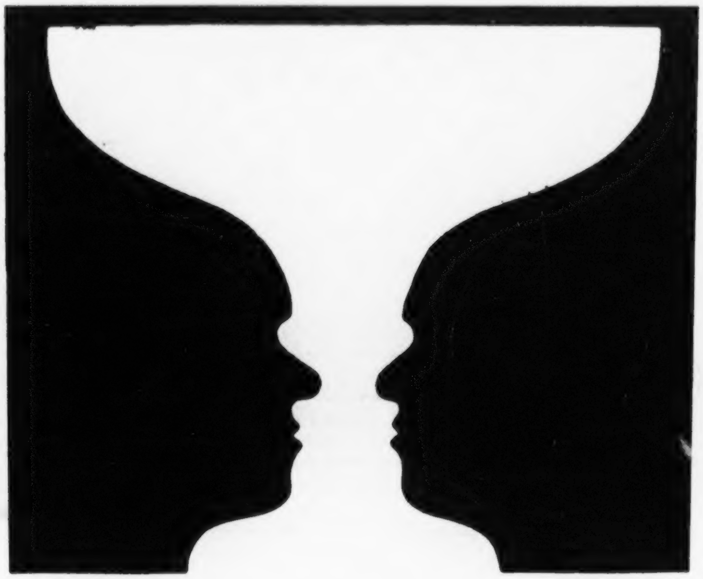
______________________________________________________________________

3. Look at the corner of the box closest to you for a minute. Which corner is now the closest to you? ______________________________



4. What are you looking at here, two people face to face or a wine glass?

______________________________________________________________________

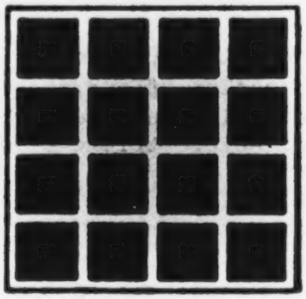


## LABORATORY WORKSHEET 1.2 (continued)

NAME ______________________________

5. Look at the white strips, especially where they intersect. Where did the circular gray shadows come from? Why do they keep moving? ______________

______________________________________________________________



6. What conclusion can you arrive at after examining your data (answers)?

______________________________________________________________

______________________________________________________________

______________________________________________________________

7. How does this experiment explain why several witnesses to a bank robbery may describe the bandits differently?

______________________________________________________________

______________________________________________________________

8. How should we decide which witness (if any) to believe?

______________________________________________________________

______________________________________________________________

# Lesson 4: WHAT KINDS OF EQUIPMENT DO SCIENTISTS USE?

AIM: "What equipment will we be using in science this year?"

PERFORMANCE OBJECTIVES: The students will be able to:

- identify a variety of equipment commonly found in school laboratories.
- relate the equipment to its use.

MATERIALS: Laboratory Worksheet 1.3, tray containing various types of lab equipment, i.e.: beaker, flask, test tube, test tube holder, a burner, meterstick, air condenser, water condenser, vegetable coloring, (if available: triple beam balance, graduated cylinder).

MOTIVATION: "You are a carpenter--what are your tools?"
"You are a scientist--what tools do you need?"

## DEVELOPMENT

1. Distribute Laboratory Worksheet 1.3 and display tray of materials.
2. Instruct students to follow the directions on the worksheet and complete the exercise in 10-15 minutes.
3. Develop worksheet chart on the chalkboard. Students should correct their own charts.

## FOR FURTHER THOUGHT

- Show an air condenser and a water condenser. Use vegetable coloring to show the separate parts of a water condenser. Ask: "How might we use these pieces of equipment?"

# LABORATORY WORKSHEET 1.3

NAME ______________________________ CLASS _____________ DATE _____________

PROBLEM: What equipment will we be using in science this year?

INTRODUCTION: The purpose of this lesson is to acquaint you with some of the equipment that you will be using this year.

MATERIALS: Variety of laboratory equipment.

PROCEDURE

1. Carefully examine each piece of equipment on the tray at your table.
2. Using the chart on the following page, and the reference sheet "Common Scientific Equipment," write on the chart the names of as many pieces of scientific equipment as you can. Then write the purpose of each item in the space provided on the chart.

SUMMARY/HOMEWORK

1. Why is it necessary to have many different kinds of equipment in a laboratory?

   ______________________________________________________________________

   ______________________________________________________________________

2. Choose three of the items. Tell what they are used for? Why is each well suited for its use?

   ______________________________________________________________________

   ______________________________________________________________________

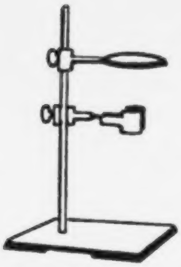
## LABORATORY WORKSHEET 1.3 (continued)

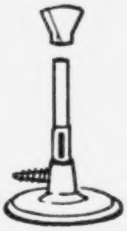
NAME ______________________________

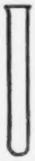
Laboratory equipment

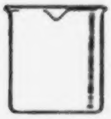
| Name | Use |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |

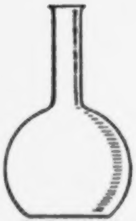
# COMMON SCIENTIFIC LABORATORY EQUIPMENT

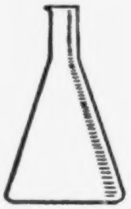

RING STAND

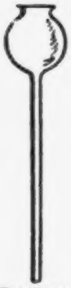

BUNSEN BURNER

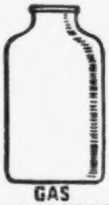

TEST TUBE

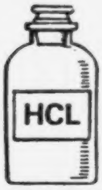

BEAKER


FLORENCE FLASK

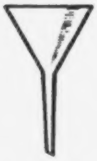

ERLENMEYER FLASK

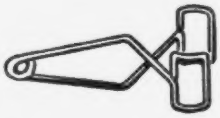

THISTLE TUBE

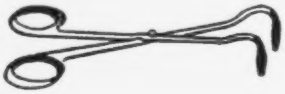

GAS COLLECTING BOTTLE

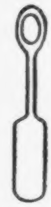


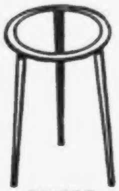
REAGENT BOTTLE

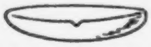

FUNNEL

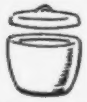

TEST TUBE CLAMP

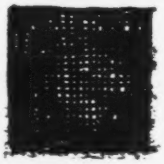

TONGS

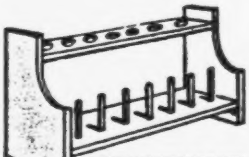

SPATULA

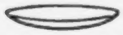

TRIPOD

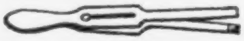

EVAPORATING DISH

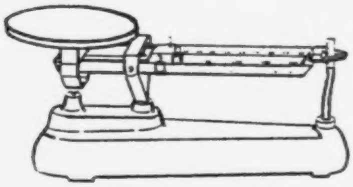

CRUCIBLE

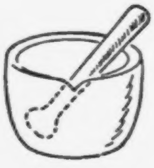

WIRE GAUZE

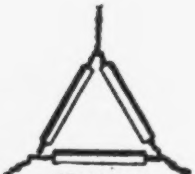

TEST TUBE RACK

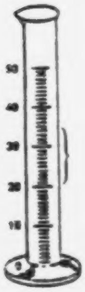

WATCH GLASS


FORCEPS

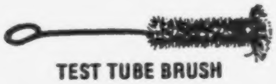

TRIPLE BEAM BALANCE

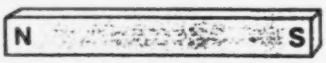

MORTAR AND PESTLE


TRIANGLE

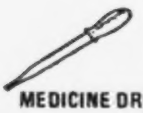


GRADUATED CYLINDER


TEST TUBE BRUSH



BAR MAGNET


MEDICINE DROPPER

## Lesson 5: LABORATORY SAFETY

AIM: "How can we prevent accidents in the laboratory?"

PERFORMANCE OBJECTIVES: The students will be able to:

- recognize the need for proper handling and use of equipment.
- identify careless behavior as the cause of many accidents in the science classroom.
- describe some precautions that should be taken when handling equipment and chemicals.

MATERIALS: Alcohol burner(*see warning), Bunsen burner, flask, test tubes, test tube rack, test tube holder, broken test tube, beakers of plain and colored water, test tubes of different colored solids, bottles of water labeled acid, base, copper nitrate [$Cu(NO_3)_2$, .1M] solution, concentrated ammonium hydroxide ($NH_4OH$) solution.

MOTIVATION: Display a broken piece of glassware. (CAUTION: Do not allow students to touch broken glassware.) Ask: "What hazard does this pose?"

DEVELOPMENT

1. "How are these displayed materials related to the equipment we studied in our first laboratory exercise?"

2. Present a student volunteer with test tubes containing $Cu(NO_3)_2$ and concentrated $NH_4OH$ (CAUTION: caustic) and an empty flask. Lead student to mix solutions. Ask class: "What do you observe?" then "What accident could have happened?" "What rule can you formulate regarding mixing unknown substances to prevent accidents?"

3. Use other available materials and develop inherent dangers and proper handling techniques for each. (How to light a burner correctly, open bottles, etc.)

4. Ask: "Why is our behavior in the science laboratory just as important as handling equipment properly?" The following rules and procedures may be discussed with the class:

*WARNING: When alcohol burners are to be used, they must be filled by the teacher, never by the students. See Caution at the beginning of this guide about the use of laboratory burners.

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## SCIENCE SAFETY RULES

a. Report all accidents to your teacher at once.

b. If any substance spills on you or gets into your eyes, wash your eyes at the eye wash station with water and notify your teacher at once.

c. Do not perform unauthorized experiments. Follow directions.

d. If any glassware breaks, inform your teacher at once. Do not touch the broken glass nor use chipped test tubes or beakers.

e. Waft odors toward your nose and then sniff cautiously to avoid damage to your nasal passages and lungs.

f. Never handle the apparatus or chemicals in the laboratory until you have been instructed how to handle them safely.

g. Don't wear loose-fitting clothing that can accidentally come into contact with science apparatus, reagents, or flames.

h. Do not carry dangerous chemicals from one place to another.

i. Do not taste chemicals or other unknown materials.

j. Read the specific safety instructions for each laboratory activity that you will perform.

k. Never pour reagents back into bottles.

l. Steel wool should be handled carefully to avoid getting any fragments into the skin.

m. Do not touch any hot materials with your hands.

n. Always point the mouth of a test tube away from yourself and from others when heating it.

o. Do not look directly at the sun; be especially careful when working with lenses and mirrors in sunlight.

p. Do not use thermometers as stirring rods.

q. Immediately report spilled mercury to your teacher.

r. Wear approved eye protectors such as safety goggles whenever working with corrosive chemicals, heating liquids, or processing solids that may shatter.

## SUMMARY

1. Referring to broken glassware, ask:

    a. "What might have caused this item to break?"

    b. "How might this breakage have been prevented?"

    c. "What would you do if you had broken this item?"

2. Ask similar questions for the other safety rules discussed.

## FOR FURTHER THOUGHT

- "How can your knowledge of proper laboratory procedure help prevent accidents at home?"

# UNIT 2. DIMENSIONS

## Note to the teacher

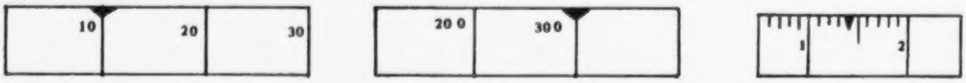
FIND OUT IF YOUR STUDENTS ALREADY KNOW THE MATERIAL IN UNIT 2 BY USING THE PRETEST THAT FOLLOWS.

TEACHERS WHO FIND THAT THEIR STUDENTS HAVE ALREADY MASTERED THIS MATERIAL MAY DECIDE TO SKIP THIS UNIT AND PROCEED TO UNIT 3.

# Pretest

NAME__________________________________CLASS_____________DATE_______________

1. A student weighed an object in the laboratory. Below is a representation of riders on the beams of a triple beam balance. How much does the object weigh?



a) 1.201 g  b) 311.4 g  c) 560 g  d) 125 g

2. When massing an object on a triple beam balance, the object to be massed is placed on the:
   - a. balance pan
   - b. beam
   - c. weight
   - d. screw

3. All systems of measurement:
   - a. are based on the number 10
   - b. must have a unit of measure and measuring instruments
   - c. must be registered in Washington, D.C.
   - d. must be accepted universally

4. A meterstick is used to measure:
   - a. length
   - b. musical intervals
   - c. density of a liquid
   - d. all of the above

5. How many millimeters are there in a centimeter?
   - a. 100
   - b. 1,000
   - c. 10
   - d. none

6. A unit of volume measurement in the metric system is the:
   - a. liter
   - b. millimeter
   - c. centimeter
   - d. kilogram

7. Gram is to kilogram as meter is to:
   - a. liter
   - b. millimeter
   - c. centimeter
   - d. kilometer

# Pretest

NAME ____________________________ page 2

8. The length of the average meterstick is:
   a. 1 meter
   b. 100 cm
   c. 1000 mm
   d. all of the above

9. The unit which represents 1/100 of a meter is the:
   a. millimeter
   b. centimeter
   c. kilometer
   d. micron

10. Which unit is closest to the diameter of a dime?
   a. kilometer
   b. meter
   c. millimeter
   d. micrometer

11. Which of the following is not used to measure volume?
   a. graduated cylinder
   b. graduated beaker
   c. protractor
   d. graduated pipette

12. One cubic centimeter equals:
   a. 1 liter
   b. 1 meter
   c. 1 milliliter
   d. 1 kilometer

FOR QUESTIONS 13-17, indicate which metric units would be the most convenient to measure the following:

13. The distance from New York to Boston
   a. millimeters
   b. centimeters
   c. meters
   d. kilometers

14. The length of your desk
   a. millimeters
   b. centimeters
   c. meters
   d. kilometers

15. The amount of gasoline in the gas tank of your car
   a. milliliters
   b. centiliters
   c. liters
   d. kiloliters

# Pretest

NAME ____________________________

16. The amount of milk in a glass
    - a. milliliters
    - b. centiliters
    - c. liters
    - d. kiloliters

17. The mass of a candy bar
    - a. milligrams
    - b. centigrams
    - c. grams
    - d. kilograms

18. Your height is measured in
    - a. meters
    - b. centimeters
    - c. grams
    - d. liters

19. A balance measures
    - a. mass
    - b. volume
    - c. degrees
    - d. length

20. Which of the following symbols would be found on a triple-beam balance?
    - a. g
    - b. cm
    - c. mm
    - d. °C

21-25. In each instance indicate which unit is larger:

21. __________ centimeter, millimeter

22. __________ centimeter, kilometer

23. __________ gram, milligram

24. __________ milligram, kilogram

25. __________ liter, milliliter

## Lesson 1: HOW DO WE USE THE METERSTICK?

AIM: "How long is this room?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe the meterstick.
- use the meterstick to measure various objects.
- deduce that precision may be needed in using the meterstick.

MATERIALS: Meterstick, metric ruler, Laboratory Worksheet 1.4, 1 foot ruler.

MOTIVATION: Hold up a meterstick and a 12 inch ruler and ask: "Why would a scientist use the metric ruler rather than the foot ruler for measuring objects?" "Explain your answer." "Estimate the length of this room in meters?" "Let's find the room's true length by an actual measurement."

### DEVELOPMENT

1. Distribute Laboratory Worksheet 1.4 and guide students through the procedures.
2. Let each group measure the length of the room independently
3. Have them measure objects less than a meter by using the length of their fifth finger. (Conversions within the metric system should not be discussed in this lesson. This topic will be treated separately in the next lesson.)
4. The students should try measuring from the end of the meterstick and also try the same measurement starting at the 10 cm mark of the stick.

### SUMMARY

- See Laboratory Worksheet 1.4.

### *HINTS FOR THE TEACHER

1. Metersticks often differ in length. Unless there are metal ends on the meterstick, the wooden part will often be worn. Prove this by comparing a few vertical meter sticks on a table top.
2. An interesting supplementary activity is to compare the lengths of a plastic meterstick and a wooden meterstick. The two metersticks are rarely the same length. This points out the need for the standard measure for comparison.

# LABORATORY WORKSHEET 1.4

NAME________________________________CLASS____________DATE______________

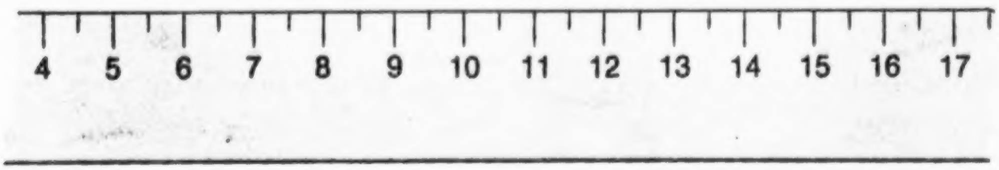
PROBLEM: How do we use the meterstick?

INTRODUCTION: The meter is the basic unit of length in the metric system. A meterstick is a convenient measuring instrument used for measuring lengths in that system. Today, we will study the meterstick and learn how to use it properly.

MATERIALS: Meterstick, metric ruler.

PROCEDURE

1. Examine the meterstick (a sample section appears below).



   a. You can see many lines dividing the stick into equal spaces. How many numbered spaces are there on a meterstick? ____________

   b. How many of these numbered spaces make up 1 meter? ____________

   c. Each numbered space represents the fraction of a meter called a __________.

   d. Why is it impractical to number the smaller spaces on the meterstick also?

   ______________________________________________________________________

   ______________________________________________________________________

2. Use the meterstick to measure the items assigned by your teacher. Record your results.

# LABORATORY WORKSHEET 1.4 (continued)

NAME ______________________________

| Object Name | My Measurements | Other Groups' Measurements | | |
|---|---|---|---|---|
| 1. length of room | | | | |
| 2. height of your desk | | | | |
| 3. width of door | | | | |

3. Examine your small metric ruler. How does its numbering differ from that of the meterstick?

______________________________________________________________________

______________________________________________________________________

a. Find the space between the fifth and sixth centimeter marks on the metric ruler. How many small spaces are there in that centimeter? __________

b. How many of these small units would there be in one meter? ________

How did you determine this? ______________________________________

______________________________________________________________________

c. Each of these spaces is called a millimeter. Why is it given this name?

______________________________________________________________________

______________________________________________________________________

d. Each millimeter space is 1/_____ of a centimeter. (Hint: See your answer to 3a.)

e. Why is the number 10 important in the metric system?

______________________________________________________________________

______________________________________________________________________

f. Measure three small objects with the metric ruler and enter your measurements on the following chart.

## LABORATORY WORKSHEET 1.4 (continued)

NAME ______________________________

| Object Name | My Measurements | Other Groups' Measurements | | |
|---|---|---|---|---|
| 1. length of 5th finger (start at 3rd crease) | | | | |
| 2. pen | | | | |
| 3. diameter of a quarter | | | | |

SUMMARY/HOMEWORK

1. Why would different groups get different measurements for the length of the room? For the length of a person's fifth finger?

2. The United States is the only major country in the world not completely using the metric system. Today you have seen some of the advantages of this system. Write a persuasive letter addressed to your local representative in Congress explaining why we should switch to this system. Give arguments and examples.

## ADDITIONAL IN-CLASSROOM ACTIVITIES

MATERIALS: Metric ruler, metric tape measure.

DEVELOPMENT

1. Using a meterstick, measure in centimeters and record:
   a. the length and width of your science book
   b. the length and width of a radiator
2. Using metric tape, measure in centimeters and record:
   a. the distance around your waist
   b. the distance around your neck
   c. the distance around your wrist
3. Metric units of length (post and hand out):

| Unit | Symbol |
|---|---|
| kilometer | km |
| meter | m |
| centimeter | cm |
| millimeter | mm |

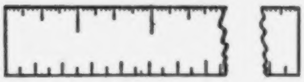
4. Refer class to the conversion chart shown in Lesson 3, Development 1.
5. Discuss with students some of the commonly used metric units of length. Cameras, automobiles, bicycles and many tools are manufactured to metric specifications.
6. Distribute handout, "Common Scientific Measuring Instruments." After students put copies in their folders, ask:
   a. Which of the illustrated measuring devices do you recognize?
   b. How do you use each of these measuring devices to obtain accurate and precise measurements?

ESSENTIAL VOCABULARY

1. accurate
2. precise
3. convert
4. estimate
5. instrument
6. measurements
7. metric

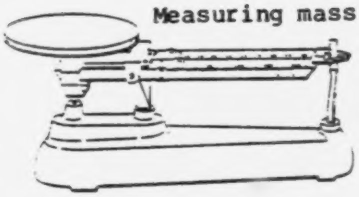
# COMMON SCIENTIFIC MEASURING INSTRUMENTS

*Measuring length*



RULER

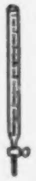
**Measuring mass**



TRIPLE BEAM BALANCE

*Measuring volume*

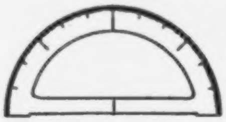
GRADUATED CYLINDER



BURETTE

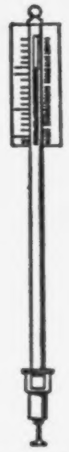
PIPETTE

*Measuring angles*

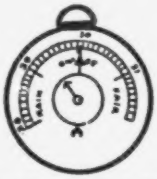


PROTRACTOR

*Measuring air pressure*

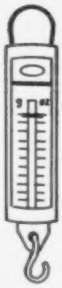


MERCURY BAROMETER



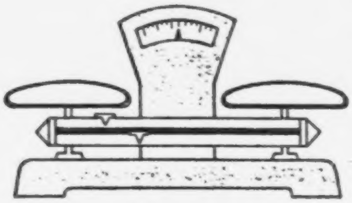
ANEROID BAROMETER

*Measuring weight (mass)*



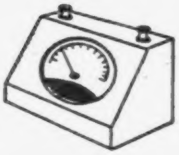
SPRING SCALE

**Measuring mass by comparing weights**



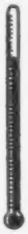
DOUBLE PAN BALANCE

*Measuring electricity*



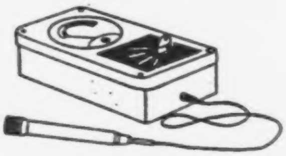
ELECTRIC METER

*Measuring temperature*



THERMOMETER

*Measuring nuclear radiation*



GEIGER COUNTER

## Lesson 2: METRIC LINEAR MEASUREMENT

PERFORMANCE OBJECTIVES: The students will be able to:

- determine the relationship among the units of the metric system.
- convert within the units of the metric system.
- use decimal notations to express metric measurements.

MATERIALS: Laboratory Worksheet 1.5, meterstick, metric ruler.

MOTIVATION: Draw a line on the chalkboard that measures 25.3 cm. Have class estimate its length. Have a student measure the line. Ask: "What can cause difficulties in making this measurement?"

DEVELOPMENT

1. Refer back to Worksheet 1.4, Procedure 3f. (Remind students that the worksheets are to become part of their notebooks.) Ask: "What is the relationship between millimeters and centimeters?" Have one student reproduce his or her activity results on the chalkboard. Develop decimal relationships between cm and mm (include decimal notations). Culminate with a comparative chart such as the one below:

| To change | to | multiply |
|---|---|---|
| centimeters<br>meters<br>kilometers | millimeters<br>centimeters<br>meters | centimeters by 10<br>meters by 100<br>kilometers by 1000 |
| **To change** | **to** | **divide** |
| millimeters<br>centimeters<br>meters | centimeters<br>meters<br>kilometers | millimeters by 10<br>centimeters by 100<br>meters by 1000 |

2. Have students revise their chart (see #1 above).

3. Distribute Worksheet 1.5.

SUMMARY

- Refer to Laboratory Worksheet 1.5.

# LABORATORY WORKSHEET 1.5

NAME__________________________________CLASS_____________DATE_______________

PROBLEM: How can we make more precise metric measurements of length?

INTRODUCTION: It is often necessary to read between the lines of a metric ruler. You will now have an opportunity to learn and apply this skill.

MATERIALS: Metric stick, metric ruler.

## PROCEDURE

1. Using the meterstick, measure and record your lab partner's height.

   _____________m ______________cm ________________mm

2. Using the metric ruler, measure the length of your partner's right thumb. Record this length below:

   _____________m ______________cm ________________mm

## SUMMARY/HOMEWORK

1. The basic unit of length measurement in the metric system is the _____________.
2. How many centimeters are there in a meter?____________
3. How many millimeters are there in a meter?____________
4. How many millimeters are there in a centimeter?________
5. Why would the millimeter be a poor unit to measure the distance between New York and Chicago?

   ____________________________________________________________________

   ____________________________________________________________________

6. Suggest a way to make long distance measurements using metric units.

   ____________________________________________________________________

   ____________________________________________________________________

## Lesson 3: LIQUID METRIC MEASUREMENT — I

AIM: "How can we measure the volume of a liquid in a test tube?

PERFORMANCE OBJECTIVES: The students will be able to:

- measure the volume of a liquid using a graduated cylinder.
- define the meniscus as the curve that water surface forms in the cylinder.

MATERIALS: Test tube rack with four 6 in. test tubes, battery jar, graduated cylinders able to hold at least 100 ml, glass marker to indicate the level that 1 liter of water will reach on the battery jar.

MOTIVATION: "A doctor tells you to put 5 cc of medicine into each eye to treat an infection. How can you be sure that the correct amount is inserted?"

### DEVELOPMENT

1. Distribute Laboratory Worksheet 1.6 to the class.
2. Construct an outline for a chart (needed for Worksheet Procedure 3) on the board. Use as headings: "Group Number" and "Amount of Water Added."

### SUMMARY

- Refer to Laboratory Worksheet 1.6.

### *HINT FOR THE TEACHER

For Worksheet 1.6, Procedure 2(b): Point out that all volume measurements in a graduated cylinder are read at the bottom of the meniscus. Thus, if 10 ml of water is to be poured from a graduated cylinder, both the initial and final readings should be from the bottom of the meniscus.

# LABORATORY WORKSHEET 1.6

NAME ______________________ CLASS __________ DATE __________

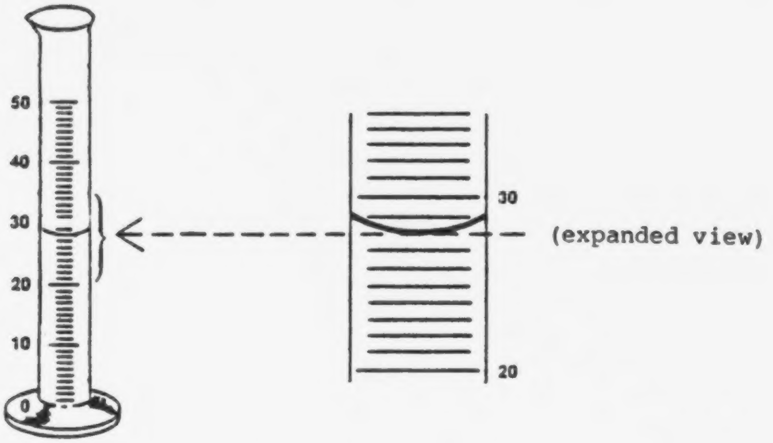
**PROBLEM:** How can we measure the volume of a liquid in a test tube?

**INTRODUCTION:** The liter measures the space occupied by a liquid. A milliliter is a subunit of a liter. Today you will become familiar with the basic laboratory instruments used to measure the volume of liquids.

**MATERIALS:** Test tube rack with four 6 in. test tubes, graduated cylinder, battery jar marked at the 1 liter level, medicine dropper, 250 ml beaker filled with water.

## PROCEDURE

1. Examine the graduated cylinder (a sample section appears below).



   a. Into how many units is the cylinder divided? ____________

   b. What is each of these units called? ____________________

   c. How many of these units are needed to fill a liter container? _____

   d. How many times must you fill the graduate to have one liter of liquid? ________________

2. Fill a test tube to the top with water.

   a. Pour the water into a graduated cylinder. How much water did the test tube hold? ______________ml

# LABORATORY WORKSHEET 1.6 (continued)

NAME ______________________________

b. Note the curve of the water surface in the graduated cylinder. This is called the meniscus (see diagram). The reading is taken at the bottom of the meniscus. Be sure your eyes are level with the meniscus when you take your reading.

c. Read the water level in the graduated cylinder again. ________ml
Does this answer differ from your answer to 2a? _________. Why?

____________________________________________________________________

____________________________________________________________________

d. Partially fill your emptied test tube. Estimate how much water it contains. ____________ml

e. Add the water in the test tube to the water already in the graduated cylinder.
How much water does the cylinder now contain? _________ml
How much water did your test tube contain? _________ml
Why is an estimation (as above) not always desirable?

____________________________________________________________________

____________________________________________________________________

3. Empty the water from the graduated cylinder into the battery jar at the front of the room.

a. Record the amount of water held by the battery jar on the chart on the board.

b. How much water must be added to fill the empty battery jar to the one-liter line? ____________ml

c. Name two items that you can purchase in the supermarket that are marked in liters:

_________________________; _________________________.

4. (Optional)

a. Fill a medicine dropper with water from the beaker.

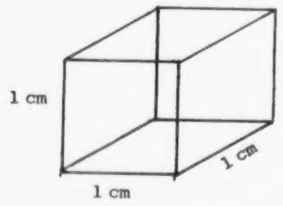
b. Slowly drop the water (counting the drops) into an empty graduated cylinder to reach the 2 ml line. How many drops of water are there in a ml?___________
How many ml are there in a drop of water?____________

# LABORATORY WORKSHEET 1.6 (continued)

NAME ______________________________

SUMMARY/HOMEWORK

1. Examine the cube below and answer the questions:



length ____________cm
width ____________cm
height ____________cm
volume ____________$cm^3$
(length x width x height)

a. How many units of a graduated cylinder would liquid from this cube fill?________________

b. What is the name of each of the units on the graduated cylinder? ________________.

c. How many cubes of liquid would it take to fill a liter container? ________________.

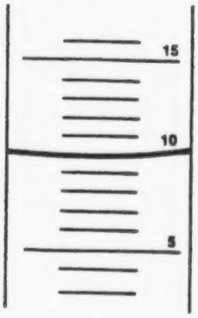
2. How are cubic centimeter units related to liters?

______________________________________________________________________

______________________________________________________________________

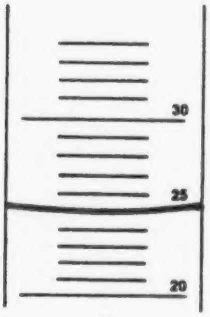
3. Study each diagram on the following page and then record the number of milliliters in the proper place. If the meniscus falls between two lines, estimate your answer.

# LABORATORY WORKSHEET 1.6 (continued)



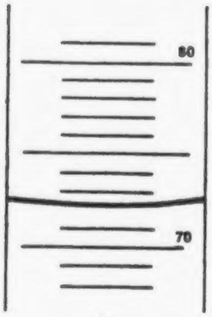
____ ml

A



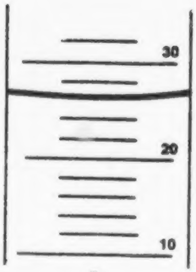
____ ml

B



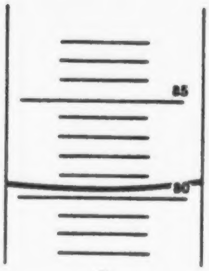
____ ml

C



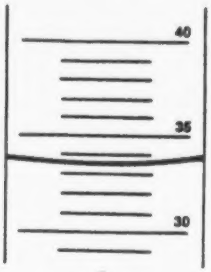
____ ml

D



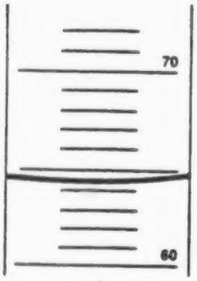
____ ml

E



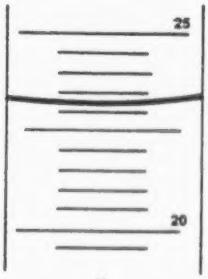
____ ml

F



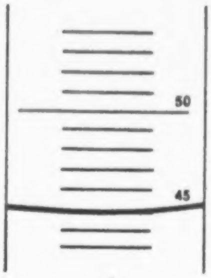
____ ml

G



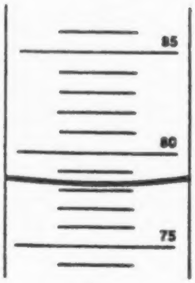
____ ml

H



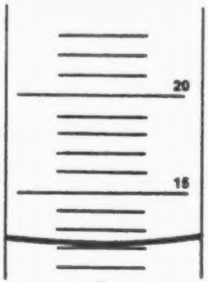
____ ml

I



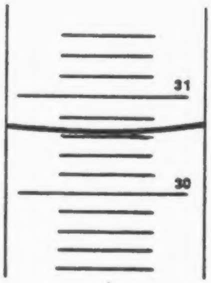
____ ml

J



____ ml

K



____ ml

L

## ADDITIONAL IN-CLASSROOM ACTIVITIES

MATERIALS: Plastic graduated cylinder or glass graduated cylinder with cylinder guard. (Since cylinders are expensive, demonstrate the safety precautions that should be followed in their use.)

### DEVELOPMENT

1. Demonstrate various types of apparatus used for volume measurement, i.e., different sizes of graduated cylinders, burettes, pipettes, beakers and flasks (with graduations). Measure 50 ml of $H_2O$ in each of the containers.

   Make sure that class knows that a graduated cylinder:

   a. should never be used for heating substances.
   b. should only be used for measuring.

2. "Name five items in your refrigerator that are measured by volume." "What is the volume of each?"

### ESSENTIAL VOCABULARY

1. apparatus
2. occupy
3. cube
4. unit
5. volume
6. meniscus

## Lesson 4: LIQUID METRIC MEASUREMENT — II

AIM: "How can we determine the volume of liquids in oddly shaped containers?"

PERFORMANCE OBJECTIVES: The students will be able to:

- define volume as the amount of space occupied by a substance.
- apply appropriate units to measurement of liquid volume.
- identify the instruments used to measure liquid volume.

MATERIALS: Variety of glassware, metric ruler, empty rectangular milk container, one-liter graduated cylinder, one-liter graduated beaker, graduated pipette, battery jar. (Optional: cube of 1000 cubic centimeters.)

MOTIVATION: Show examples of differently shaped containers filled with the same amount of water. Ask: "Which container appears to contain the most water?" "How can we find out which one actually contains the most water."

### DEVELOPMENT

1. Ask student volunteers to test liquid measurements suggested by class in response to motivation question. Develop concept of "cubic" centimeter using a rectangular milk container. Define the term volume--the amount of space occupied by a substance.

2. Ask: "Why is it inconvenient to use the cubic centimeter to measure the volume of water in a reservoir?" Develop the liter as a unit of measurement for liquids. Relate 1 cubic centimeter to 1 liter.

### SUMMARY

- Display a graduated pipette. Ask: "How can this pipette be used to add a desired quantity of water into a container?"

### FOR FURTHER THOUGHT

1. "Why is a graduated cylinder a convenient device to measure the volume of liquids?"

2. "How does the centimeter ruler provide a means for measuring liquids?"

3. "Why are volume measurements used for measuring both liquids and gases?"

* **NOTE TO TEACHER:** An excellent visual aid is the dissectible 1000 cubic centimeter cube. Each edge is 10cm long and sections of cubic centimeters may be removed and examined. Another visual aid can be made by taping the ends of 12 full length meter sticks together to make a hollow cube with a volume of 1 cubic meter. See how many students can fit inside this cube.

# Lesson 5: USING THE THERMOMETER

AIM: "How can we measure the temperature of our classroom accurately?"

PERFORMANCE OBJECTIVES: The students will be able to:

. use a Celsius thermometer to measure a variety of temperatures.

MATERIALS: See Worksheet 1.7.

MOTIVATION: Refer to the experiment from a previous lesson and the need for measuring temperature accurately.

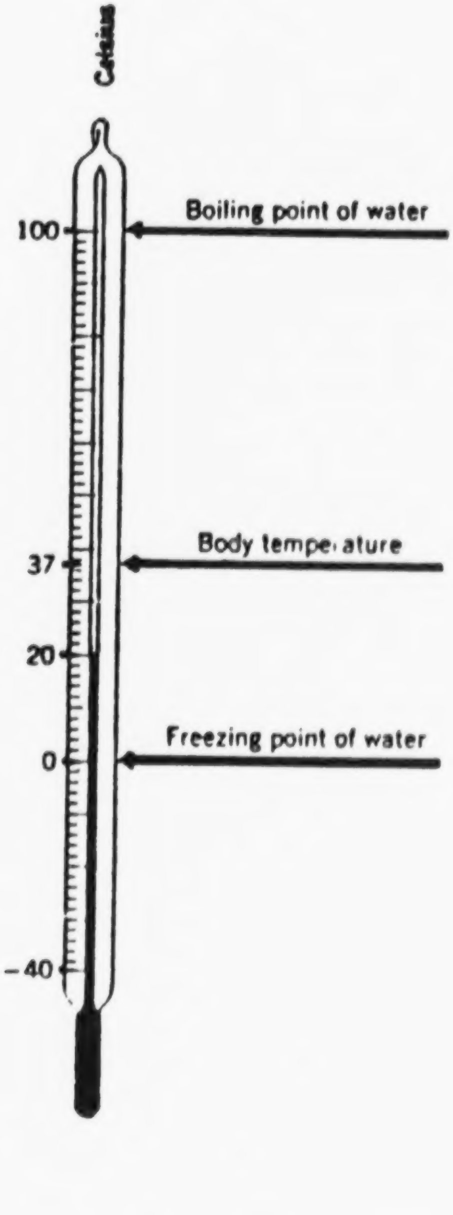
## DEVELOPMENT

1. Set up several half-filled beakers of boiling water, preferably prior to the beginning of the lab session. A hot plate can be used to boil the water. Use gloves or beaker tongs to remove beakers.
2. Distribute Laboratory Worksheet 1.7. Review safety procedures with students concerning the use of boiling water.
3. Caution class in use of thermometers. Demonstrate proper procedures for handling and reading thermometers. They break easily, can cause injuries, and are expensive to replace. Remind students not to touch the bulb. Also, if a mercury thermometer breaks, students are to avoid contact with the mercury.
4. After students complete Procedure 5 on the worksheet, supply them with the average temperatures for the chart.

## SUMMARY

. See Laboratory Worksheet 1.7.

* **NOTE TO TEACHER**: Carefully review the use of thermometers and proper procedures for reading a thermometer. Make a transparency of the illustration of a thermometer. The room temperature in your classroom may not be 20°C. Discuss the use of average temperature in determining calibration points on a thermometer.


Celsius
Boiling point of water
100
Body temperature
37
20
Freezing point of water
0
−40

# LABORATORY WORKSHEET 1.7

NAME ______________________________ CLASS ______________ DATE ________________

PROBLEM: How can we measure the temperature of our classroom accurately?

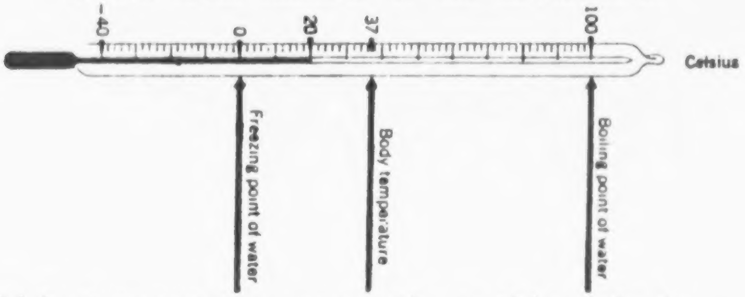
MATERIALS: Celsius thermometer, mercury or alcohol, beakers of boiling water on tripods or on hot plates, wire gauze, tongs, beakers of ice.

INTRODUCTION: An instrument that measures temperature in degrees is the thermometer. Today you will be studying a temperature scale called the Celsius scale. This is now the universal temperature scale (used throughout the world) and is part of the metric system of measurement. A unit of heat measurement is the calorie. It is THE AMOUNT OF HEAT THAT WILL RAISE THE TEMPERATURE OF ONE MILLILITER OF WATER BY ONE DEGREE ON THE CELSIUS SCALE.

PROCEDURE

1. Examine the temperature scale on the thermometer, an illustration of which appears below. Then answer questions 1a-1c, which refer to the illustration.

DO NOT TOUCH THE BULB OF THE THERMOMETER!



a. The highest temperature measurable on this scale is ________________.

b. The lowest temperature measurable on this scale is ________________.

c. The total number of degrees on this temperature scale is ____________.

2. Allow the thermometer to rest on your table for about one minute. Then record the temperature it registers in the column marked Classroom Readings, Room Temperature, on the chart attached to this lab sheet. Why is this called the room temperature?

______________________________________________________________________

______________________________________________________________________

## LABORATORY WORKSHEET 1.7 (continued)

NAME ______________________________

3. Measure your body temperature by the following method. (If time permits, other members of your lab group may also try this.) Place the bulb of the thermometer in the center of your armpit and lower your arm, holding it as close to your body as you can. (Did you know that this is how temperature is taken in most of the world?) Be careful to support the thermometer so that it does not tip or break. After three minutes, record your body temperature on the chart.

4. Place the thermometer carefully into the boiling water on the demonstration table. Record the temperature of the boiling point of the water on the chart.

5. Allow the bulb of your thermometer to cool before you place it in ice water. (Do you know why this is necessary?) Then place it into the beaker of ice water at your table. Record the Ice Temperature on your chart.

6. Complete the chart by finding the difference between the average Celsius temperatures found by the rest of the class and those you have recorded.

CELSIUS TEMPERATURE CHART READINGS

| | Your Values | Class Average | Difference | Reasons for difference |
|---|---|---|---|---|
| ROOM TEMPERATURE (°C) | | | | |
| BODY TEMPERATURE (°C) | | | | |
| TEMPERATURE OF BOILING WATER (BOILING POINT) | | | | |
| TEMPERATURE OF ICE WATER (FREEZING POINT) | | | | |

# LABORATORY WORKSHEET 1.7 (continued)

NAME ______________________________

SUMMARY

1. The Celsius scale used to be called the centigrade scale.

   a. The prefix "centi" means ____________________.

   b. If a centimeter is one-hundredth of a meter, why is this temperature scale called the centigrade scale?

SUMMARY/HOMEWORK

1. Compare a fever thermometer, an outdoor-indoor type thermometer, an oven thermometer, or any other temperature measuring instrument you may have at home to those you studied in class today?

2. The thermometers you have at home may use a Fahrenheit scale. If so:

   a. Find the boiling point, freezing point, and body temperature used on the Fahrenheit scale.

   b. Calculate the number of degrees on the Fahrenheit scale between the boiling and freezing points of water. Why is this number more difficult to remember than the comparable temperature differences on the Celsius scale?

## Lesson 6. MASS VS WEIGHT

AIM: "What is the difference between mass and weight?"

PERFORMANCE OBJECTIVES: The students will be able to:

- explain the difference between mass and weight.
- cite instances where the mass remains constant and the weight changes.
- calculate the weight of an object on earth, given its mass in kilograms.
- measure the mass of an object using a triple beam balance.

MATERIALS: Kilogram masses, strings, Laboratory Worksheet 1.8.

MOTIVATION: Hold up a kilogram mass and ask, "Although this brass cylinder would be weightless in outer space, it could hurt you badly if a fellow astronaut threw it at you during an interplanetary flight. Why?"

DEVELOPMENT

1. Suspend several masses from strings and have students try to make each mass move rapidly by flicking it with an index finger.

2. Weigh each of the masses on a newton balance and record the weights, in newtons, on the chalkboard. (If newton balances are unavailable, use a balance calibrated in kilograms. Cover the scale readings with tape so 1 kg is changed to 10 newtons, 2 kg is changed to 20 newtons, 3 kg is changed to 30 newtons etc. This conversion will result in a 2% error which is acceptable for these imprecise scales.)

3. Elicit that the weight of an object depends on the gravitational pull of the earth. On the earth, a mass of 1 kilogram weighs 9.8 newtons.

4. Have students recall that the weight of an object becomes less and less as it gets further away from the earth. At great distances from the earth, the weight becomes negligible but the mass of the object does not change.

5. Perform sample calculations to show how the weights of objects on the earth can be calculated by multiplying mass, in kilograms, by 9.8. Follow this by a short drill in which the students are given a list of masses, in kilograms, and are required to calculate the corresponding weights, in newtons.

6. Present a list of weights, in newtons, and have students calculate the corresponding masses, in kilograms.

7. Provide an opportunity for the students to express their concept of mass vs weight in writing. Ask them to summarize the differences between mass and weight in two or three sentences.

8. Ask: "If mass and weight are different, why is it that grocers in metric countries have no difficulty when they use KILOGRAMS as a unit of weight? In fact most grocers are completely unaware that there is any difference between mass and weight."

9. Elicit that scientists and astronauts must consider the difference between mass and weight because a kilogram of mass has different weights during interplanetary travel. On the other hand, grocers are always on the surface of the earth where a kilogram mass has almost the same weight, regardless of location. Therefore, as far as grocers are concerned, there is no need to distinguish between mass and weight.

SUMMARY

- Ask: "Why is it becoming increasingly necessary for us to distinguish between mass and weight?"

# LABORATORY WORKSHEET 1.8

NAME________________________________CLASS____________DATE______________

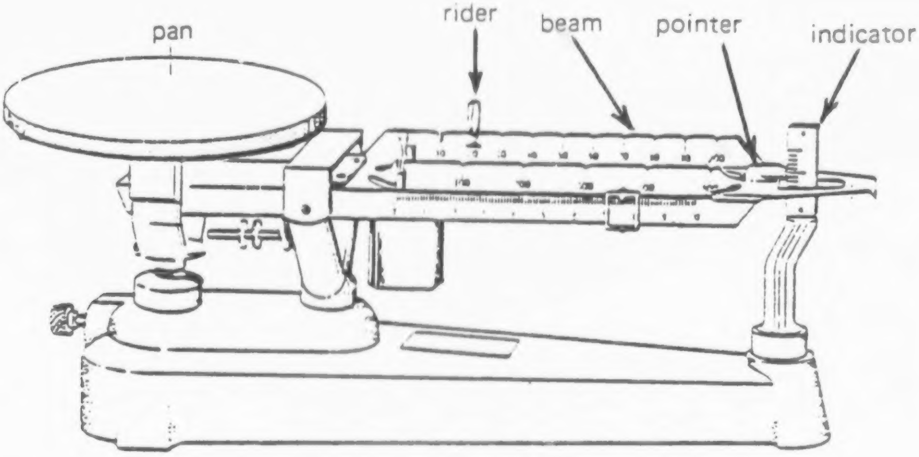
PROBLEM: How can we measure the mass of a glass of water accurately?

INTRODUCTION: A unit of mass in the metric system is the GRAM (g). Metric mass is measured in the science laboratory by the measuring device called a triple beam balance. Today you will learn how to use a triple beam balance to measure the masses of common objects.

MATERIALS: Triple beam balance, standard masses, beaker, water, coins, and other objects, drinking glass.

PROCEDURE

1. Examine the triple beam balance on your table. A simplified diagram of the balance appears below:



   a. What is the function of the balance pan?

   ______________________________________________________

   b. What is the function of the beams with riders?

   ______________________________________________________

# LABORATORY WORKSHEET 1.8 (continued)

NAME ____________________________

c. How do the three beams differ from each other?

________________________________________________

d. Examine each beam and its rider. What unit of measure is indicated by all three beams?

________________________________________________

e. Why must the riders on two of the beams be in the notches rather than in between the notches?

________________________________________________

f. When you move the rider one notch on the middle beam, how much additional mass is indicated?

________________________________________________

g. When you move the mass on the rear beam, how much additional mass is indicated?

________________________________________________

h. Why is this called a triple beam balance?

________________________________________________

i. What is the mass of the heaviest object that can be massed on this balance? How did you arrive at this answer?

________________________________________________

2. The triple beam balance is a delicate instrument that, if mishandled, can lose its accuracy. Do not play with the balance. Now you will test the balance.

a. Select a standard mass and place it on the balance pan.

b. Adjust the riders on each beam until a balance is reached. How do you know when this happens?

________________________________________________

# LABORATORY WORKSHEET 1.8 (continued)

NAME ____________________________

c. Record the mass indicated by the riders of your balance: ____________ Is it the same as the number marked on the standard mass? Explain why the two values may not be identical.

______________________________________________________________

______________________________________________________________

3. Practice makes perfect

a. Mass the empty water glass. Record its mass. ________
Fill the glass with water. What is the total mass? ________
What was the mass of the water in the glass ? ________

b. How many glasses of water did your teacher drink if he drank 946 grams? ________

c. Select at least three other items to mass. (You may use some coins, your pen, pencil, ruler, etc.)

d. List the items in order of the RELATIVE masses that you estimate by holding them in your hands. How does this use of your hands use the same principle as the balance?

______________________________________________________________

______________________________________________________________

| Items by estimated mass | Mass using a balance |
|---|---|
| Lightest | |
| | |
| Heaviest | |

Were the estimated masses correct? If not, explain. ______________

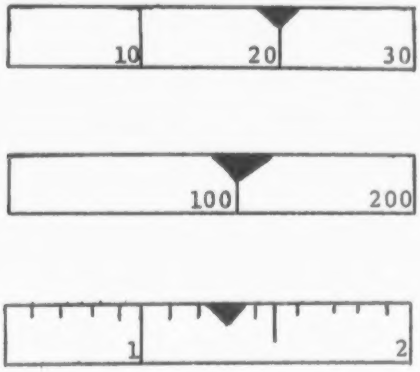
______________________________________________________________

# LABORATORY WORKSHEET 1.8 (continued)

NAME ______________________________

SUMMARY/HOMEWORK

1. Below is a representation of the beams of a balance after placing an orange on the pan. What is the mass of the orange? ________ grams.



2. Design a beam balance which you could use to find your mass in metric units.

## Lesson 7: METRIC MEASUREMENT RELATIONSHIPS

AIM: "How are a gram, a milliliter, and a centimeter related?"

PERFORMANCE OBJECTIVES: The students will be able to:

- relate the gram to other metric units.
- describe the basis of uniform measurements.
- relate milliliters of water to grams of water.

MATERIALS: Laboratory Worksheet 1.9.

MOTIVATION: Refer to results in Laboratory Worksheet 1.8, and list some objects and their masses. Ask: "Why do scientists prefer massing objects on a balance to estimating the relative masses by lifting?"

DEVELOPMENT

1. Distribute Laboratory Worksheet 1.9 to the class.

2. Ask: "Why is it necessary for all countries to adhere to the same standards of metric measurement?" This should challenge the class to appreciate a system of worldwide standards. (Hint: 1 liter in France = 1 liter in United States)

SUMMARY

- See Laboratory Worksheet 1.9.

# LABORATORY WORKSHEET 1.9

NAME____________________________________CLASS_______________DATE_______________

PROBLEM: How are a gram, a milliliter, and a centimeter related?

INTRODUCTION: We have seen that there is a relationship between the units of volume and linear measurements (1 = 1 ml). Today you will see how the gram, the milliliter and the centimeter are related in the metric system.

MATERIALS: Triple beam balance, graduated cylinder, water.

PROCEDURE

1. How much does a milliliter of water weigh?

   a. Mass an empty 25 ml graduated cylinder on your balance and record the mass. ________ grams.

   b. Fill the graduate to the 10 ml mark and mass it again. Record the mass of the graduate and the water. ________ grams.

   Calculate the mass of the water alone? ________ grams.

   If 10 ml of water has a mass of ________ grams, then 1 ml of water must have a mass of ________.

   c. Empty the graduated cylinder and fill it with water to the 5 ml line.

   Mass it with the water and record the weight. ________ grams.

   The mass of 5 ml of water alone is ________ grams.

   The mass of 1 ml of water is ________ grams.

   d. Mass 1 ml of water. Why is it more accurate to mass more than 1 ml and then divide the mass by the number of milliliters?

   ____________________________________________________________

   ____________________________________________________________

# LABORATORY WORKSHEET 1.9 (continued)

e. How are the milliliter and the gram of water related?

________________________________________________

________________________________________________

2. Complete the Sentences

a. One milliliter of water has a mass of ________________gram(s).

b. One milliliter of water equals ________________ cubic centimeter(s).

c. One cubic centimeter of water has a mass _____________gram(s).

d. A milliliter is a unit of (volume, length, weight). Select one.

e. A gram is a unit of (volume, length, mass). Select one.

f. A centimeter is a unit of (volume, length, weight). Select one.

g. __________ $cm^3$ = __________ ml = ________ g [For water only.]
how many? how many? how many?

SUMMARY/HOMEWORK

1. Explain how the units of length, volume, and mass are related in the metric system.

2. The Canadian dollar has a different value than the United States dollar. How do we know that the Canadian gram has exactly the same value as the United States gram?

## Lesson 8: REVIEW OF METRIC UNITS

AIM: "How well have I learned the units in the metric system?"

[OPTIONAL] (It is suggested that teachers not doing this lesson duplicate the letters and assign them as homework.)

PERFORMANCE OBJECTIVES: The students will be able to:

. relate metric units to common objects.
. evaluate his or her comprehension of metric units.

MATERIALS: Graduated cylinder, triple beam balance, meterstick, spring balance gram scale (optional), variety of materials to measure, boxes of empty food products that show mass or volume.

MOTIVATION: "Some people say that learning to use the metric system is as hard as learning to speak a foreign language. What is your opinion of this viewpoint?"

DEVELOPMENT

1. Reproduce the following letters (they are repeated on the student sheet for ease of duplication). Have students fold the student sheet page on the dotted line.

2. Have students fill in the blanks in the letter that Juanita wrote to her friend on October 2. Appropriate units may be selected from the following list:

gram
kilogram

meter
centimeter
millimeter

liter
milliliter

October 2, 19___

Dear ____________

Boy, was I suprised this morning when I stepped on the scale. I found that my mass was 60 _____________. I couldn't believe my eyes. I used a tape measure and found my waist measured 70 ____________. Do you think this is too much for someone who is 1.7 ____________ tall? I decided to go on a diet and exercise.

For breakfast I had 120___________ of orange juice, 30_________ of cereal with 100__________ of milk. After breakfast, I walked 1,500____________.

I really hope this works. I will write you soon to let you know if I lost any weight.

Your friend,

Juanita

3. Ask: "How many of you took more than two minutes to complete the exercise?" "Why?" Develop a visual relationship between metric units and size. Some materials to use include: 1 liter soda bottle, single serving cereal box, etc. Have students pour 120 ml of water into a cup, mass 30 grams of chalk, etc. Go over the student exercise letter with class and have students place correct answers on the chalkboard.

3. Use the letter of October 9 as a summary to see if performance has improved. Go over the answers with the class.

SUMMARY

October 9, 19___

Dear ____________

I have great news. In just one week I have lost 950 _______ and lost 2 ______ from my waist. Never again will my breakfast consist of 500 ________ of soda and 250 _______ of potato chips.

Your friend,

Juanita

FOR FURTHER THOUGHT

1. "What difficulties are preventing the United States from fully converting to the metric system?"

2. "What reasons can you give favoring a full conversion to the metric system in the United States?"

# STUDENT SHEET

## LETTERS TO A FRIEND

NAME ______________________________

. Fill in the blanks in the two letters that Juanita wrote to her friend. Appropriate units may be selected from the following list:

gram
kilogram
meter
centimeter
liter
milliliter
millimeter

October 2, 19___

Dear ____________

Boy, was I suprised this morning when I stepped on the scale. I found that my mass was 60 _______. I couldn't believe my eyes. I used a tape measure and found my waist measured 70 _______. Do you think this is too much for someone who is 1.7 ___________ tall? I decided to go on a diet and exercise.

For breakfast I had 120___________ of orange juice, 30_________of cereal with 100__________of milk. After breakfast, I walked 1,500____________.

I really hope this works. I will write you soon to let you know if I lost any weight.

Your friend,

Juanita

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

October 9, 19___

Dear ____________

I have great news. In just one week I have lost 950 _______ and lost 2 ______ from my waist. Never again will my breakfast consist of 500 ________ of soda and 250 _______ of potato chips.

Your friend,

Juanita

## ADDITIONAL IN-CLASSROOM ACTIVITY

1. Ask students who have visited other countries what system of measurement was used. Have students interview friends and relatives, asking them the same question. Make a list of the people who have been interviewed and of the information the students receive.

2. List ten common items found in the supermarket and the metric weight of each. What did you observe about the masses of most items packaged by weight or mass in your supermarket?

ESSENTIAL VOCABULARY

1. centi-
2. milli-
3. kilo-
4. prefix
5. balance

## Lesson 9: TESTING MEASURING SKILLS — LAB PRACTICAL

AIM: "How accurate are our measuring skills?"

PERFORMANCE OBJECTIVES: The students will be able to:

. apply the various skills learned over the last few weeks.

MATERIALS: Empty milk containers (to test the skills of linear and weight measurement), a graduated cylinder (to test volume measurement), Laboratory Worksheet 1.10.

DEVELOPMENT

1. After obtaining empty milk containers, cut them to varying heights to create a different sized container for each group.
2. Place an identifying letter on each container. (The teacher should keep a record of the volume of each container distributed to the class).

. Students should work in laboratory groups of three to five students. Although group interaction is desirable, the teacher should monitor the class to insure that each student participates equally.

# LABORATORY WORKSHEET 1.10

NAME______________________________ CLASS____________ DATE______________

PROBLEM: How good are your measuring skills?

INTRODUCTION: In our most recent lessons, you have acquired a number of measuring skills. Today you will have an opportunity to demonstrate these skills under test conditions.

You will be graded on accuracy, technique, and group cooperation. Answers must be written in appropriate units in the spaces provided.

Before you begin, read the entire Procedure section carefully and plan the approach you will take to arrive at the correct answer.

MATERIALS: Triple beam balance, metric ruler, graduated cylinder, beaker of water, empty container.

PROCEDURE

1. Measure the height of the empty container. ____________
2. Measure the width of the empty container. ____________
3. Measure the depth of the empty container. ____________
4. Using the measurements above, calculate the volume of your container. ____________
5. Calculate the mass of 123 ml of water. ____________
6. Pour 123 ml of water into your container and actually measure the mass of this water. ____________
7. How does your calculated mass of 123 ml of water compare with its actual mass? ____________

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## Note to the teacher

THOSE TEACHERS WHO COVERED THE MATERIAL IN UNIT 2 MIGHT WISH TO TEST THEIR STUDENTS BY ALLOWING THEM TO RETAKE THE PRETEST FOUND AT THE BEGINNING OF THIS UNIT.

# UNIT 3. SCIENTIFIC REASONING

# Introduction

This unit consists of six lessons.

1. Preparation for Home Laboratory Study
2. Preparation of an Experimental Plan - I
3. Preparation of an Experimental Plan - II
4. How Is an Experiment Carried Out?
5. How Does a Scientist Work?
6. Experimental Procedure

Explain the purpose of the experiment that students will do at home, and assign a due date. Their results will be discussed in Lesson 6 of this unit. The purpose of this unit is to introduce the students to the need for careful and critical thinking when answering scientific questions. To this end, the nature of the scientific method is introduced with its associated concepts of hypotheses, observations, inferences, and controls. Emphasis is placed on the students designing their own experiments, and on interpreting their own data.

Several additional concepts should be introduced in this unit.

1. The scientific process is a lengthy one. Answers are not usually obtained overnight.

2. Scientific data must be interpreted by humans. Conclusions, therefore, may differ depending on who makes the interpretation.

3. There are rarely right or wrong answers in science. The tentative nature of hypotheses and theories is what causes scientists to alter their theories in the light of new evidence obtained through new observations or through better interpretations of old observations.

4. Inferences are interpretations advanced by scientists to explain what is observed in the laboratory. Different students may make opposing inferences from the same observations, depending on their background, knowledge, and sophistication.

   Unit 3 is an introduction to the ways of the scientist. Thus, students are not required, for example, to learn the formula for the boiling point elevation for aqueous solutions. In this unit, process is separated from content. In the other units, the two are joined again to provide a more comprehensive approach to the study of science.

## Lesson 1: PREPARATION FOR HOME LABORATORY STUDY

AIM: "Where should mung beans be germinated?"

MATERIALS: See Home Laboratory Study sheet which follows for list of materials.

MOTIVATION: Bean sprouts are grown for food on farms, in gardens, and even in pots on window sills of apartments. People use them in salads and in other dishes. Your next task as a scientist is to scientifically determine the best place to grow them in your house.

### DEVELOPMENT

1. Distribute Home Laboratory Study and Laboratory Report. Assign a due date and have students write it in the space provided in step 7 of the instructions.

2. Preparation for this home lab will include:

   a. Mung beans (Chinese bean sprout seeds) can be easily obtained in supermarkets especially in Chinatown, in health food stores, or in garden supply stores.

   b. Prepare a kit containing six bean seeds, two plastic drinking cups, two pieces of transparent wrap and two pieces of paper toweling for each student.

   c. Review each step of the directions. You may want to demonstrate the steps.

   d. Point out and emphasize the due date you have written into step 7 of the Home Laboratory Study.

   e. Stress that all students will be required to bring results to class.

3. The Laboratory Report sheet will be due in about five school days. The students are not yet ready to complete these sheets at this time.

# HOME LABORATORY STUDY

## THE GROWTH OF BEAN SEEDS

NAME________________________________________SCIENCE CLASS__________________

### MATERIALS

1. mung beans, or other large, quickly germinating seeds
2. two plastic cups, (5 oz)
3. clear plastic food wrap
4. absorbent paper toweling
5. water

### DIRECTIONS FOR GROWING BEAN SEEDS

1. Place some moistened paper toweling on the bottom of each growth container. (Be certain that the toweling is NOT soaking wet).
2. Place three bean seeds on top of the moist material in each container.
3. Cover each container with clear plastic food wrap.
4. Place one of the containers in a drawer, closet, or warm, dark corner. Place the second container in the refrigerator.
5. EACH DAY, check each cup to determine if water is needed. (DO NOT over-water, or allow to dry out. Paper towel should remain moist at all times.) Remember to moisten those in the refrigerator as well as those in the warm, dark place.
6. Using the form which follows (and any additional paper you may need), keep a careful record of observations that you make each day. It is a good idea to record your observations when you remoisten the seeds. Be certain to observe your seeds each day of the growth period. REMEMBER, IF NO CHANGE OCCURS, THIS IS AN OBSERVATION TOO!
7. The growth experiment will continue for five days (or more, if your teacher prefers). Your laboratory report on this experiment is due in class on ________________ (DAY), ______________ (DATE). All parts of the report must be completed. You may do this as the experiment proceeds, or when all observations have been completed.
8. Your grade for this experiment will count as a test. You will not be graded on your results, but on how you have recorded your results and how you have used the SCIENTIFIC METHOD of discovery.

DO NOT THROW YOUR MATERIALS AWAY. YOU WILL BE REQUIRED TO BRING YOUR RESULTS TO CLASS TOGETHER WITH YOUR LABORATORY REPORT.

## LABORATORY REPORT

| DAY | DATE | OBSERVATIONS<br>REFRIGERATED CUP | <br>WARM CUP (kept in drawer or closet) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |

This laboratory report should contain the DESIGN AND CONCLUSION of your home study experiment involving the growth of bean seeds. All information should be obtained from the ACTUAL SETUP OF YOUR EXPERIMENT, YOUR OBSERVATIONS, and the CONCLUSIONS YOU REACH at the end of the study. Use the SCIENTIFIC METHOD outlines developed in class to guide you in writing this report.

# ADDITIONAL IN-CLASSROOM ACTIVITY

This experiment may also be performed in class. Daily observations are recorded on a chart on the bulletin board at the beginning of each period for about five school days.

## ESSENTIAL VOCABULARY

1. germinating
2. absorbent
3. moist
4. observation
5. design
6. problem
7. hypothesis
8. outline
9. control
10. conclusions

## Lesson 2: PREPARATION OF AN EXPERIMENTAL PLAN — I

AIM: "When we boil an egg, what is the effect of adding salt to the water?"

* **NOTE TO TEACHER:** You may choose either this lesson or Lesson 3. The idea of this lesson is to use the Aim as a vehicle to generate hypotheses and to introduce the scientific method of solving problems. This lesson is continued in Lesson 4, p. 97.

* **NOTE TO TEACHER:** It is important that the student realize that there is no accepted answer to this question. The idea of this lesson is to use the question "Why do we add salt to water when we boil an egg?" as a vehicle to generate hypotheses and to introduce the scientific method of solving problems.

PERFORMANCE OBJECTIVES: The students will be able to:

. develop an awareness of the importance of accurate observations.
. use observations to form experimental procedures.
. reduce the need for scientific reasoning.

MATERIALS: Beaker, tripod, wire gauze, alcohol burner, 100 ml water, 10 g table salt, raw egg, tongs.

MOTIVATION: Set up materials to boil an egg -- then add salt. Lead to the question, "Why do cooks add salt to water when they boil an egg?"

DEVELOPMENT

1. Refer to the Motivation. Ask: "Why did I ask this question?" Develop concept that observation leads to questions that need to be answered.

2. Have students suggest possible answers and defend them. Have class vote for the most acceptable response. (If necessary, teacher should add suggestions to the list including the effect of salt on the boiling temperature of water.) Conclude that vote results were based on observations and experience. Ask: "Is this good enough?"

3. Ask: "Why can't we accept the class's decision?" "What should we do now?"

4. Have students write down steps they might use to develop an answer to the question.

5. Ask several students to present their procedures to the class.

6. Through guided discussion, select those steps that would best answer the question. Discuss the need for a control.

## SUMMARY

1. "Why do observations lead to questions?"
2. "Why can't questions in science be solved by a vote?"

## FOR FURTHER THOUGHT

. "How can observations lead to solutions?"

# Lesson 3: PREPARATION OF AN EXPERIMENTAL PLAN — II

AIM: a. "Is there something in the human breath which can cause plants to wilt?"

AND/OR

b. "When viewed through a solid glass rod, why do some words appear to be upside down while the rest are right side up?"

PERFORMANCE OBJECTIVES: The students will be able to:

- develop an awareness of the importance of accurate observations.
- formulate hypotheses.
- use observations to formulate an experimental plan.
- generate the concept of the importance of a control in an experiment.

MATERIALS: Mimosa plant that reacts to stimuli, and/or glass stirring rod [solid], index cards with the following typed sentences, one card for each pair of students:

DICK HID MARY'S BOOK

CHECK EVERY DEED

BOB HID RAY'S BIKE

MOTIVATION: a. Tell the class that all your life you have been bothered by something in your breath despite the use of the advertised mouth washes and the most expensive breath fresheners. (Exhale vigorously on the healthy mimosa plant.)

AND/OR

b. Distribute cards and glass rods to the class. Tell the students to hold the rod about a centimeter above the printing on the card. They have the right height when the letters seen through the glass are slightly enlarged and can be read without difficulty. Move the rod over each sentence, one at a time and observe how some words are inverted, while others are unaffected.

DEVELOPMENT

1. Record some of the students' observations on the chalkboard. Develop the concept that observations lead to questions to be answered.

2. Have students suggest and defend possible causes for the effects. Introduce the term "hypothesis" as being a possible, logical answer.

3. Have the class vote for the most acceptable hypothesis. Lead students to conclude that the results of voting were based on observations and previous knowledge and experiences.

4. Ask why, as scientists, we can't accept the majority decision of the class? Ask: "What should we do to find scientifically acceptable answers."

5. Have several students present their experimental plans to the class.

6. Through guided discussion, select the procedures that would best answer the question.

7. Discuss the need for controls.

## SUMMARY

1. "Why do observations lead to questions?"

2. "Why can't questions in science be solved by a vote?"

## FOR FURTHER THOUGHT

- "How can observations lead to solutions?"

## Lesson 4: HOW IS AN EXPERIMENT CARRIED OUT?

AIM: "What is the effect of hot salt water on an egg?"

[Or have class investigate an hypothesis which is an outgrowth of the previous lesson.]

PERFORMANCE OBJECTIVES: The students will be able to:

- direct the performance of an experiment.
- make and record observations.
- draw conclusions based on observations.

MATERIALS: Beaker, tripod, wire gauze, Bunsen burner, water, 10 g table salt, raw eggs, tongs (or equipment and materials determined in previous lesson).

MOTIVATION: "Now that the experiment is designed, let's see how it works."

### DEVELOPMENT

1. Elicit step-by-step procedure. Record each step on the chalkboard. Use student volunteers to assist in performing the experiment with a control and to record observations.

2. Ask: "What conclusions can you draw from this experiment?" List the conclusions on the board.

3. Compare conclusions to the hypothesis. Ask: "Why do conclusions sometimes lead to problems for further investigation?" Elicit examples.

4. For the egg experiment, discuss the need for the thermometer as a tool in continuing this investigation.

### SUMMARY

1. "Why is this experiment an example of a scientific method?"

2. "Why do we sometimes reach conclusions that are unrelated to the hypothesis?" "What is the value of these conclusions?"

3. Assign this experiment if the egg experiment was not selected to be done in class.

   PERFORM THIS EXPERIMENT AT HOME

   a. Crack two raw eggs slightly. Allow some of the white to escape.
   b. Place one egg in a pan of boiling water.
   c. Place the other egg in a pan of boiling water to which one "pinch" of salt has been added.
   d. What are your observations?
   e. Your conclusion?

## FOR FURTHER THOUGHT

. "Select one of the new problems raised by the results of our experiment. Design an experiment to resolve this problem. Be sure to include a control."

* **NOTE TO TEACHER:** Some further problems raised by the egg experiment which you may wish to present to the students for their consideration are listed below:

1. "As the water boils, some of it evaporates. The control (water + egg, but no salt) does not increase in temperature appreciably. The salt water does increase in temperature as time goes on. "How does each of these phenomena affect the expermental results?"

2. "Does the boiling point temperature of the salt water solution increase indefinitely as the water evaporates?"

3. **FOR TEACHER INFORMATION ONLY**

   The boiling point of an aqueous solution increases by an amount proportional to the number of particles dissolved in the water. The change in the normal boiling temperature of water is given by the formula $\Delta T = .52mi$, where "m" is the molality and "i" is the number of particles given off by the dissolving solute "molecules." For NaCl (table salt), i=2.

   If a teaspoon (about 1 oz) of NaCl is added to 500 grams of water (about 1 pint), the molality is calculated to be:

   $$\frac{28g\ NaCl}{58.5\ g/mole\ NaCl} \div .500\ kg\ of\ water = .96\ m$$

   Thus, the calculated change in the boiling point of the water turns out to be $\Delta T = .52 \times .96 \times 2 \cong 1^\circ C$. The water will boil at $101^\circ C$ rather than $100^\circ C$. If half this amount of water is used, the boiling point would be $102^\circ C$.

   It can be seen that adding a "pinch" of salt to a large amount of water will have no appreciable affect on the boiling point of water, and hence, no effect on cooking time.

4. "Pure water will boil at $100^\circ C$ (under normal conditions) no matter how high the flame on the stove. Does this suggest a way to conserve energy?"

## Lesson 5: HOW DOES A SCIENTIST WORK?

AIM: "What is wrong with this experiment?"

PERFORMANCE OBJECTIVES: The students will be able to:

- evaluate a scientific research paper.
- list essential elements of an experimental procedure that were omitted.
- conclude that a large number of samples must be in both the experimental and control groups.
- identify negative results as having significance.

MATERIALS: Laboratory Worksheet 1.11

MOTIVATION: "In the acid precipitation experiments that are being conducted all over the world, some scientists think that acid rain and snow are caused by industrial pollutants. Let's read what one scientist reported and examine it carefully in the light of what we have learned."

DEVELOPMENT

1. Distribute Laboratory Worksheet 1.11.

2. Guide students through it by having it read aloud (or by silently reading).

SUMMARY:

- See Laboratory Worksheet 1.11.

# LABORATORY WORKSHEET 1.11

NAME______________________________ CLASS___________ DATE_____________

**PROBLEM:** What is wrong with this experiment?

**INTRODUCTION:** This is a report of an actual experiment on crop damage due to acid rain done by Thomas M. Rathier. This experiment was reported in the Fall 1983 issue of "Frontiers of Plant Science."

## PROCEDURE

1. Does acid rain damage crops? If so, what does the damage look like and can it affect the appearance or yield of crops? Although popular reports on acid rain often mention damage to plants, there is little experimental evidence to confirm or deny such reports. Therefore, I performed an experiment using tobacco as the test crop.

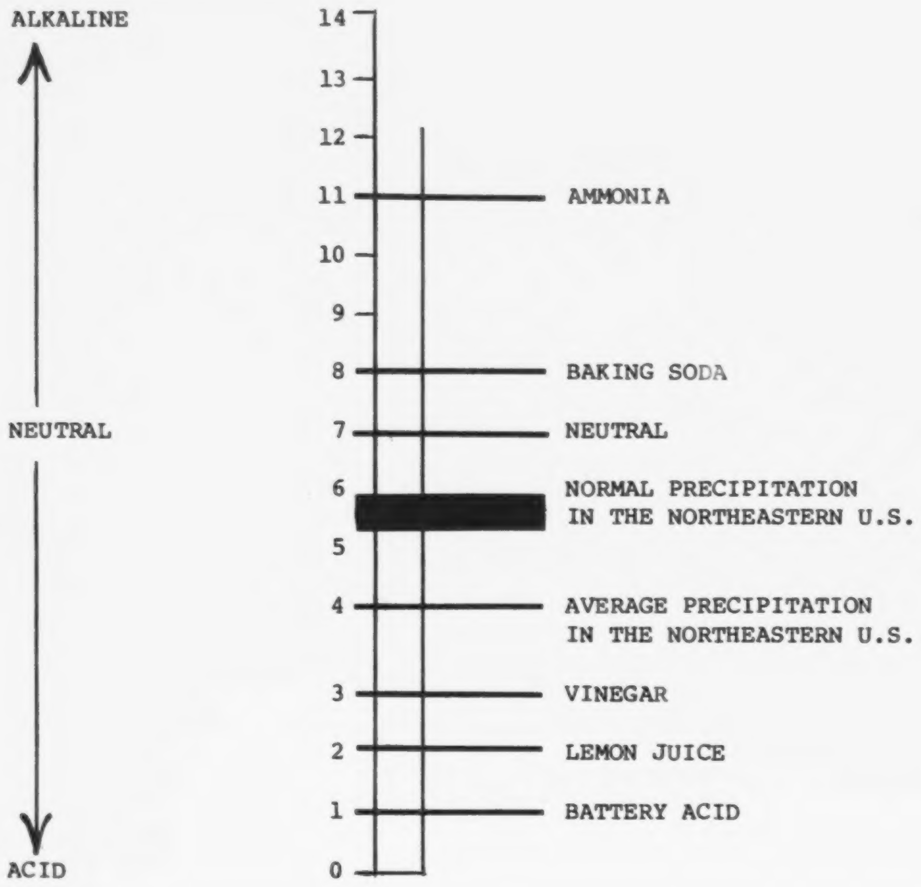
2. I chose tobacco for two reasons. First, its leaves are sensitive to damage by ozone and other air pollutants. Second, much of the tobacco grown in Connecticut depends on the appearance of its leaves for its value: a single blemish or mark can make a normally valuable leaf nearly worthless.

3. Acid rain was made by adding nitric and sulfuric acids to tap water to produce six treatments with "rain" at pHs* of 2.0, 2.5, 3.0, 3.5, 4.0, and 5.6. Since unpolluted rain has a pH of 5.6 and rain in Connecticut has an average pH of about 4.3 to 4.4, these treatments are drastic.

4. * pH is a measure of how acid or alkaline a liquid may be. pH varies from 0 to 14. A pH of 7.0 is neutral (neither acid nor alkaline). If the pH is below 7, the solution is acidic. The closer the pH is to 0, the greater is the acidity. Look at the chart that follows. Find the pH for vinegar and for battery acid.

# LABORATORY WORKSHEET 1.11 (continued)

NAME ______________________________


ALKALINE
NEUTRAL
ACID
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
AMMONIA
BAKING SODA
NEUTRAL
NORMAL PRECIPITATION IN THE NORTHEASTERN U.S.
AVERAGE PRECIPITATION IN THE NORTHEASTERN U.S.
VINEGAR
LEMON JUICE
BATTERY ACID

5. Each treatment was applied to the leaves of tobacco twice a week for one to five weeks. The plants were grown in containers with trickle irrigation to prevent irrigation water from washing the acid rain off the leaves. Also, the soil in the pots was covered to prevent the simulated acid rain from reaching the roots. The experiment was located outdoors at the Valley Laboratory in Windsor, but in a plastic house to prevent natural rainfall from washing the treatments off the leaves.

6. Damage was visible only on the plants receiving the most acidic rain at pH 2.0. Damage began as small yellow or green spots and progressed to bleached dead spots that enlarged with repeated applications. Continued application of the "rain" at pH 2.0 completely destroyed the tissue and caused a shot-hole appearance. Those leaves receiving two applications per week for five weeks were the most dramatically affected, whereas those receiving two applications for one week showed no additional damage after applications were stopped. Damage increased from about 30% of the leaves after two applications of pH 2.0 rain to 97% after ten applications.

# LABORATORY WORKSHEET 1.11 (continued)

NAME ______________________________

7. Damage from acid rain occurs only where water gathers for extended periods and the damage progresses from the exterior (outside) tissues to the interior (inside) tissues. It has been suggested that acidic water droplets remaining on leaves might evaporate and so concentrate their acidity. In my experience, all treatments had an opportunity to evaporate on the leaves, but again, damage only occurred with "rain" at pH 2.0.

8. Since rain in Connecticut has an average pH of 4.3 to 4.4, the likelihood of damage to crops is very slight.

SUMMARY/HOMEWORK

1. What was Dr. Rathier's hypothesis?

______________________________________________________________________

______________________________________________________________________

2. What was his control?

______________________________________________________________________

______________________________________________________________________

3. How many experimental groups did he use? ______________________

4. What precautions did he take to insure that his observations were correct?

______________________________________________________________________

______________________________________________________________________

5. What were his observations?

______________________________________________________________________

______________________________________________________________________

6. What vital bit of information concerning the number of plants tested was NOT included in this report?

______________________________________________________________________

______________________________________________________________________

## LABORATORY WORKSHEET 1.11 (continued)

NAME ______________________________

7. Why is it important for us to know how many plants were tested?

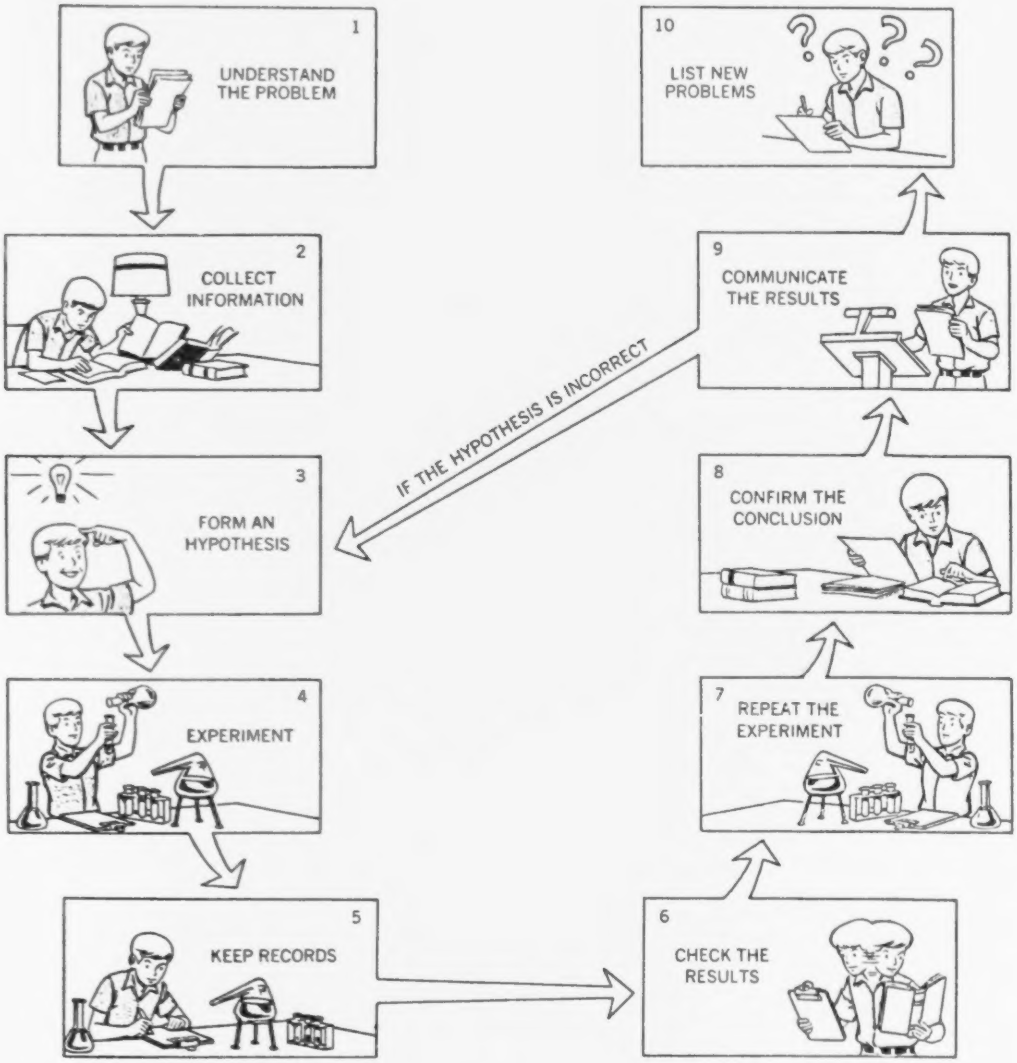
8. What was his conclusion?

9. Can we accept this conclusion as being correct without the information we wanted in question #6? Explain your answer.

10. Is Professor Rathier's conclusion a positive conclusion or a negative one?

11. Can a negative conclusion of any experiment be valuable? Explain your answer.

# A METHOD FOR EXPERIMENTATION


1
UNDERSTAND THE PROBLEM
2
COLLECT INFORMATION
3
FORM AN HYPOTHESIS
4
EXPERIMENT
5
KEEP RECORDS
6
CHECK THE RESULTS
7
REPEAT THE EXPERIMENT
8
CONFIRM THE CONCLUSION
9
COMMUNICATE THE RESULTS
10
LIST NEW PROBLEMS
IF THE HYPOTHESIS IS INCORRECT

## Lesson 6: EXPERIMENTAL PROCEDURE

AIM: "In what ways was our bean experiment done scientifically?"

PERFORMANCE OBJECTIVES: The students will be able to:

- evaluate the results of their experiment.
- relate their experiment to established experimental protocol.
- use the concept of average value to present scientific results.

MATERIALS: Laboratory report, bean plants.

MOTIVATION: Referring to the student experiments done at home, ask: "Why do some results differ from others?"

DEVELOPMENT

1. Have students meet in lab groups to compare their plants and their reports.

2. Distribute blank laboratory report to each group. Group members will cooperatively complete the sheets.

3. For each item, arrive at a consensus based on group responses. Place a sample laboratory report on the chalkboard and record the results.

SUMMARY

1. Elicit from the members of the class differences between their own lab report and the class report.

2. Ask: "Why do we accept the class conclusions even though there were differences?" "How might we explain some of these differences?"

# LABORATORY REPORT

GROUP NAMES ______________________________

State the problem.

What was your hypothesis?

What materials did you use?

Outline your experimental design. (This should include a step by step description of your procedure.)

What was your control?

Summarize your daily observations.

What conclusions did you reach as a result of your experiment?

## ADDITIONAL IN-CLASSROOM ACTIVITIES

### SUGGESTED ACTIVITIES

### Scientific Method

1. Construct an object made of different textures and colors. Use paper, cloth, lab equipment. Display the object on a demo desk. Elicit that a good observation tells many things. Observation includes the use of all our senses. List on the board the observations the class makes about the object displayed.

2. Arrange beforehand to have a student come into the room, leave a message and then depart immediately. After he or she leaves, list observations the class has made: height, color of hair and eyes, attire, etc. Elicit that observation is a careful act of watching and noticing.

   a. Divide students into groups of four. Put 10 different objects in front of each group for 5 minutes (Students may not touch the objects.) Take away the objects. Have the groups list the objects from memory.

   b. Repeat Part "A", but give a different set of objects to each group. This time have students use all their senses except taste. Take the objects away. Have students list the 10 objects from memory and see if any improvement has occurred.

### ESSENTIAL VOCABULARY

1. resolve
2. solution (referring to a problem)
3. comparison
4. data
5. interpretation
6. method
7. procedure
8. investigation
9. original
10. control

### FOR FURTHER THOUGHT

. Consult Science '82, September 1982 issue. An article answers the question, "Does a curve ball really curve just in front of the batter's box?" An experiment is illustrated which deals with this point very well.

# Theme I — Questions for Review

NAME______________________________ CLASS__________ DATE ____________________

1. The first step in setting up an experiment is to:
   - a. gather all necessary materials
   - b. define the problem
   - c. set up a data table
   - d. suggest a hypothesis

2. In an experiment, the experiment and the control must be:
   - a. exactly alike
   - b. completely different
   - c. alike in all respects but one
   - d. similar

3. A scientist's "educated guess" about a problem is usually called:
   - a. a law
   - b. a fact
   - c. an opinion
   - d. a hypothesis

4. Scientists should not:
   - a. search for evidence
   - b. have a good imagination
   - c. jump to conclusions
   - d. test a hypothesis

5. When used in a laboratory exercise, an alcohol burner:
   - a. should be left burning for the entire period
   - b. should always be left at the edge of the desk
   - c. should be extinguished when not in use
   - d. should have its wick extended to three inches

6. When heating a test tube over an alcohol flame, you should:
   - a. hold the test tube in your hand
   - b. use a test tube holder and point the test tube toward your partner
   - c. use a test tube holder and point the test tube toward empty space
   - d. look directly into the test tube to check the vapor color

7. A system of measurement must have all the following except:
   - a. a standard unit of measurement
   - b. a measuring instrument
   - c. agreement among all people using the system
   - d. a way of converting the system into English measurement

8. To measure length in the metric system we would use a unit called a:
   - a. meter
   - b. mililiter
   - c. kilogram
   - d. calorie

NAME________________________________________

9. The measurement of the space a liquid takes up is called the:
   a. mass
   b. volume
   c. gram mass
   d. calorie

10. The distance between Chicago and New York is best measured in:
   a. liters
   b. grams
   c. millimeters
   d. kilometers

11. The metric system is called a decimal system because:
   a. it is based on units of 10
   b. it has 10 different units of measurement
   c. it took 10 years to develop
   d. there are 10 meters in an inch

12. A cubic centimeter is equal to a:
   a. milliliter
   b. milligram
   c. metric liter
   d. kilometer

13. The curve of the liquid in a graduated cylinder is called a:
   a. rim
   b. meniscus
   c. ring
   d. low

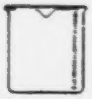
14. The volume of one gram of water is:
   a. one liter
   b. one milliliter
   c. one centimeter
   d. one decimeter

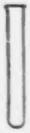
15. The step in the scientific method that enables the results to be compared is called the:
   a. problem
   b. observation
   c. hypothesis
   d. control

NAME____________________________________

QUESTIONS 16-20. Identify each of the following pieces of equipment. Select your answers from the list below.

16. _____ graduated cylinder
17. _____ beaker
18. _____ test tube
19. _____ Bunsen burner
20. _____ flask

a


c


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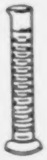

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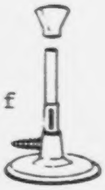

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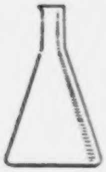
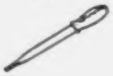
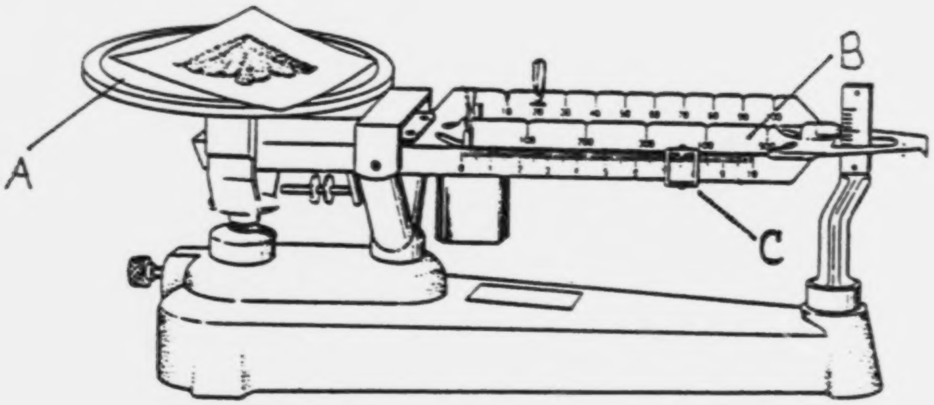


e


QUESTIONS 21-25. Refer to the diagram below.



21. The correct name for the apparatus is ______________________________.

22. The part labeled A is the ______________________________.

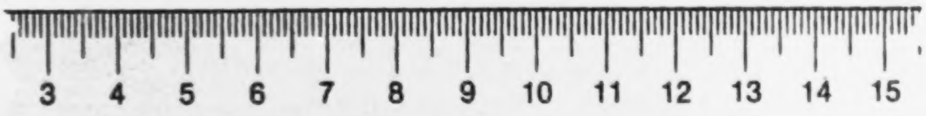
23. The part labeled B is the ______________________________.

24. The part labeled C is a ______________________________.

25. The weight (mass) registered above is ______________________________.

NAME________________________________________

QUESTIONS 26-29. Below is a section of a metric ruler. Base your answers to the following completion questions on this picture.



26. The spaces indicated by each of the numbers are units of measurement called ____________________.

27. Thirteen numbered spaces are shown on this ruler. How many spaces would have to be shown on a metric ruler that is 1 meter long? _________________

28. Examine the 10 small divisions between 5 and 6. Each of these small units is called a ____________________.

29. How many of these SMALLEST UNITS are there in one meter? _________________

True or False

30. _____ When lighting a Bunsen burner, the gas should be put on before the match is lit.

31. _____ Only heat resistant glassware should be used when heating.

32. _____ The metric unit used to measure length is the liter.

NAME_______________________________________

33. _____ Tasting a chemical in the laboratory is not permissible even if you're reasonably sure what it is.

34. _____ Never put a chemical back into a reagent bottle once it has been removed.

35. _____ A meter is the standard unit of weight measurement in the metric system.

### Essay

1. Harold has a mass of 45,450. Explain the significance of this fact.
2. Why is measurement by instruments important in science?
3. John wanted to prove that plants need light in order to live and grow. He placed a potted geranium plant in a dark closet. Three weeks later, he looked at the geranium and found that it was dead. He concluded that his experiment proved that plants need light to live and grow.
    a. Describe 3 of the experimental errors John made when he set up his experiment.
    b. Design a more acceptable experiment which John could have used to reach his conclusion.

# THEME II

# POWER SOURCES AND RESOURCES

# UNIT 1. IT'S ALL ELEMENTARY

# Introduction

An understanding of the properties of matter is prerequisite to the study of most of the energy concepts introduced in Theme II. For this reason, a review of the important chemistry concepts ordinarily studied in Grade 7 may be required by many ninth grade students.

Unit 1 presents the topics of atomic theory and chemical periodicity from the viewpoint of energy, stability, and the scientific models proposed to explain the observable properties of matter. A pretest has been provided for teachers to help them determine the extent of review that may be required before proceeding with the remainder of Theme II. The pretests in Theme II emphasize facts and principles, while the post-tests emphasize facts, principles, and higher level objectives.

The methods of presentation suggested are substantially different from those given in the present seventh grade course of study. Thus, there is little chance that any of the students who already "know" the material will be bored by reviewing it.

Much of Theme II, Unit 1 is new to the ninth grade, and all students will be able to learn from this material.

***NOTE TO TEACHER:** In Grade 7 the following areas are covered:

Elements
Compounds
Mixtures
Atomic Theory

We are enclosing a pretest so that you can see what has to be reviewed from Grade 7.

# Pretest

Unit 1 - Chemistry

NAME ______________________________ CLASS ___________ DATE __________________

1. All matter is made up of 1 or more simple substances called:
   a. compounds
   b. solids
   c. elements
   d. mixtures

2. Matter is anything:
   a. that can be seen
   b. that has mass and takes up space
   c. that has luster
   d. that has color

3. An example of a nonmetal is:
   a. sulfur
   b. magnesium
   c. sodium
   d. tin

4. The modern Periodic Table shows:
   a. an alphabetical listing of the elements
   b. elements arranged in order of increasing atomic number
   c. elements arranged in order of increasing atomic mass
   d. a list of elements and compounds

5. The similarities and differences in matter are called:
   a. states
   b. metals
   c. nonmetals
   d. properties

6. Water can be separated into its elements by:
   a. filtering
   b. boiling
   c. electricity
   d. evaporation

7. An element which has luster and malleability is most probably a:
   a. nonmetal
   b. gas
   c. metal
   d. compound

8. Elements combine chemically to form:
   a. gases
   b. mixtures
   c. liquids
   d. compounds

9. The properties of compounds are:
   a. the same as those of the elements of which they are made
   b. different from those elements of which they are made
   c. the same as the properties of mixtures
   d. the properties of the combining metal

10. The best equation for the formation of water is:
   a. $H + O \rightarrow HO$
   b. $H_2 + O_2 \rightarrow H_2O$
   c. $2H_2 + O_2 \rightarrow 2H_2O$
   d. $H_2 + O \rightarrow H_2O$

11. The smallest part of a substance which still has the properties of the substance is called:
   a. a mixture
   b. a compound
   c. an atom
   d. a molecule

12. When magnesium burns in air:
   a. heat energy is destroyed
   b. heat and light energy are produced
   c. no energy change occurs
   d. magnesium sulfide is formed

13. When iron filings are mixed with sulfur and heated:
   a. a physical change occurs
   b. an element is formed
   c. a chemical change occurs
   d. magnetism is created

14. Sugar dissolved in water is an example of:
   a. a mixture
   b. a compound
   c. an element
   d. a molecule

15. The name of a compound, written with chemical symbols, is called:
   a. an equation
   b. an element
   c. a formula
   d. a reaction

16. The atomic number of an element equals the number of:
   a. protons
   b. neutrons
   c. electron shells
   d. protons and neutrons

NAME ________________________________

17. The nucleus of an atom contains:
    a. electrons
    b. protons and neutrons
    c. only protons
    d. protons and electrons

18. The number of electrons in the K energy level of the element with atomic number 6 is:
    a. 8
    b. 18
    c. 2
    d. 12

19. Water is:
    a. a compound
    b. a mixture
    c. an element
    d. an acid

20. Metallic elements are usually:
    a. gases
    b. electron-lenders
    c. inert
    d. electron-borrowers

21. Matter with a definite shape and volume is a:
    a. solid
    b. liquid
    c. gas

22. Molecules or atoms are usually closest together in a:
    a. gas
    b. liquid
    c. solid

23. Iron filings and sulfur are put into a test tube and stirred without heating. The substance formed is:
    a. an element
    b. a compound
    c. a mixture

24. Iron filings and sulfur are put into a test tube and heated. The substance formed:
    a. is an element
    b. has the same properties as before heating
    c. is a compound
    d. releases energy

25. When steel wool is burned in air, the steel wool's mass:
    a. increases
    b. decreases
    c. remains the same

26. The positively charged nuclear particle is the:
    a. atom
    b. proton
    c. neutron
    d. electron

27. The particle that has the least mass is the:
    a. atom
    b. proton
    c. neutron
    d. electron

28. The central part of an atom is the:
    a. molecule
    b. nucleus
    c. electron cloud
    d. metallic core

29. Most elements are:
    a. metals
    b. non-metals
    c. gases at room temperature
    d. liquids at room temperature

30. Elements are arranged on the Periodic Table according to their:
    a. chemical and physical properties
    b. order of discovery
    c. alphabetical order
    d. number of neutrons

31. A physical property all metallic elements possess is they:
    a. are solids at room temperature
    b. form crystals
    c. dissolve in water
    d. have luster or shine

32. Compounds are usually composed of:
    a. solids reacting with liquids
    b. a metal reacting with a non-metal
    c. two metallic elements reacting with each other
    d. a special element

NAME ______________________________

33. Elements in Group 0:
    - a. are metals
    - b. are all solids at room temperature
    - c. have complete outermost energy levels
    - d. react easily with other elements

34. An element with one electron in its outermost energy level will tend to:
    - a. be inactive under all conditions
    - b. lose one electron to a non-metal
    - c. lose one electron to a metal
    - d. gain seven electrons

35. An element with seven electrons in its outermost energy level will tend to:
    - a. be inactive under all conditions
    - b. gain one electron from a non-metal
    - c. gain one electron from a metal
    - d. lose seven electrons

36. An element that reacts with carbon is:
    - a. silicon
    - b. magnesium
    - c. sodium
    - d. hydrogen

37. Carbon reacts by:
    - a. gaining electrons
    - b. losing electrons
    - c. adding protons
    - d. sharing electrons

38. A chemical reaction that releases energy is:
    - a. endothermic
    - b. exothermic
    - c. never useful and often dangerous
    - d. non-existant

## Lesson 1: WHAT CAUSED THE BEADS TO MOVE?

AIM: "Why do the beads jump when heated in a tube with mercury?"

PERFORMANCE OBJECTIVES: The students will be able to:

- explain that beads in the Stoeckle's tube jumped because they acquired energy from the flame.
- synthesize a model to explain specific observations.
- reason abductively, inductively, and deductively.

MATERIALS: Stoeckle's tube (see page 195), test tube holder, Bunsen burner, erasers with chalk dust, flashlight, onions, scalpels.

MOTIVATION: Display a Stoeckle's tube. Have the students describe the tube. Carefully heat the tube until the beads begin jumping.

DEVELOPMENT

1. Have the students describe what they observed when the beads jumped.
2. Ask: "What caused the beads to jump?" Explain that the heat from the flame was transferred to the test tube, then to the mercury, and finally to the beads, so the beads started to jump.
3. Darken the classroom and flash a beam of light across the room. Have the students describe the motions of the particles of air in the light beam. It should be difficult to see the air particles because air is transparent.
4. Ask a student to clap two erasers together in the beam of light. Have students observe the motions of the individual chalk particles.
5. Ask: "How do you account for the random movements of the chalk particles as they fall through the air?"
6. Distribute onions and scalpels to students. Make sure students are instructed to handle scalpels cautiously. Place the onions a few feet from the students and ask them to describe the onion's odor. Then direct the students to carefully cut the onion into small pieces and have them describe the onion's odor after it is cut.
7. Ask the students to compare the intensity of the onion's odor before and after slicing it. Ask: "How did the onion's aroma get from the onion to your nose?" Explain the aroma travelled from the onion, through the air, to the students' noses. Emphasize that our sense of sight was not used.
8. We smelled the onion, we did not "see" its aroma. Elicit that the onion is composed of molecules, and that the onion's molecules permeated the air and reached the students' noses.

9. Have the students synthesize a model that explains these three experiences. Elicit that the beads jumped because the flame heated the test tube molecules which transferred heat energy to the bead; the chalk dust particles moved randomly because they were bombarded by air molecules; we smelled the onion because onion molecules moved through the air to our noses.

10. Ask: "Which of the following models explains these three experiences?"

    a. Matter is composed of small, invisible particles.
    b. The particles may transfer their energy to other particles.
    c. The particles are constantly in motion.

11. Conclude by having the students summarize how they have formulated a model or explanation based solely upon the available information and data.

## SUMMARY

1. "What caused the beads in the test tube to jump?"

2. "Why did the beads stop jumping when the Stoeckle's tube was removed from the flame?"

3. "Why is it difficult to detect air particles before clapping the erasers?"

4. "What caused the random motion of the chalk dust particles?"

5. "Why could you smell the onion despite the fact you were a few feet away from it?"

6. "Create a model to explain why the beads and chalk dust particles moved, and why the onion aroma became evident."

## Lesson 2: HOW CAN WE LEARN ABOUT ATOMS IF WE CANNOT SEE THEM?

AIM: "How can we find out what is in the sealed box without opening it?"

PERFORMANCE OBJECTIVES: The students will be able to:

- hypothesize characteristics of unseen objects.
- create a model based upon specific observations and activities.
- explain the bases of a model.
- comprehend that scientists observe the properties of atoms by studying the behavior and characteristics of matter.

MATERIALS: Sealed box containing several objects: pencils, paper, magnet, etc.

MOTIVATION: "Scientists believe that all matter is composed of atoms or molecules, yet NOBODY HAS EVER SEEN AN ATOM! How do scientists defend the concept of an atom?"

DEVELOPMENT

1. Ask: "How can you describe an object without seeing the object?" Relate to Lesson 1 and the model the students created to explain the jumping beads, the chalk dust particles' random motion, and the detection of the onion's aroma.

2. Have students proceed with the laboratory activities and guide them through Laboratory Worksheet 2.1 The teacher may provide a list of each item present in each box or may decide to allow the students to investigate without such a list.

3. Have the students write a brief description of what they did, and what "evidence" supports their model.

4. Ask: "Why is it difficult to create a model of something you cannot see?"

SUMMARY

1. "How does the mini-lab activity relate to the way scientists arrived at our modern model of the atom?"

2. "Why do we call what we know about the atom atomic theory?"

FOR FURTHER THOUGHT

1. "More than one million atoms, side by side, would be as thick as this page. Explain this."

2. "How can we be so sure there are such things as atoms?"

# LABORATORY WORKSHEET 2.1

NAME______________________________ CLASS____________ DATE________________

PROBLEM: What is in the sealed box?

MATERIALS: Sealed box (with two or three objects in it): iron filings, magnet, metric ruler, triple beam balance.

INTRODUCTION: All matter is made up of tiny particles called ATOMS. Atoms are so small that they cannot be seen even with the aid of a microscope. Then, how do we know about atoms? Scientists observe the properties of atoms by studying the behavior and characteristics of the many forms of matter. From the results of their studies, they make models of what they believe an atom is like. Today, you will learn how such models are made by studying some objects that YOU cannot see.

PROCEDURE

1. Select a box from the front of the room. The box will contain two or three objects, and must remain sealed. Record the number of the box on the chart below.

2. You must find out as much as you can about the objects in the box without opening the box. Keep a record of what you find on the chart. (Try listening, shaking, rolling, measuring, massing, balancing, magnetism, etc.)

3. When you have completed your observations, make a sketch of what you think each object in the box looks like. (Do not try to name the objects. Remember, this is a MODEL, NOT an accurate picture.) A list of boxes and objects may be made available to you so that you might check your results and see how close you came to "picturing" each object.

THE BOX NUMBER IS____________________________

Approximately how much of the box is occupied by empty space?______________

How did you arrive at this estimate?____________________________________

______________________________________________________________________

Are there any magnetic materials in the box?______________________________

How did you find out?__________________________________________________

______________________________________________________________________

## LABORATORY WORKSHEET 2.1 (continued)

NAME ______________________________

THE NUMBER OF OBJECTS IN THIS BOX IS PROBABLY ______________________________

## PROPERTY CHART FOR MYSTERY BOX

| Project # | Size | Shape | Texture | Magnetic? | Material (Metal, plastic, etc. | Any Other Properties |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

SUMMARY/HOMEWORK

1. Describe the major problems you had in identifying the objects.
2. How does this relate to the problem scientists faced when the model of an atom was first proposed?

## Lesson 3: WHAT ARE THE PROPERTIES OF MATTER?

AIM: "How do ice, water, and steam differ?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe the three states of matter.
- compare the distances between the atoms or molecules of most solids, liquids, and gases.
- apply a model to a specific situation.
- reason inductively and deductively.

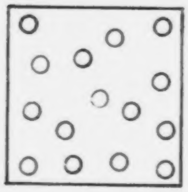
MATERIALS: A piece of ice, a beaker of water, and steam rising from boiling water.

MOTIVATION: Display the ice, beaker of water, and steam. Ask the students to explain the similarities and differences among the substances.

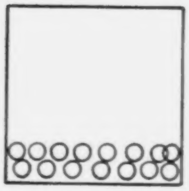
DEVELOPMENT

1. Ask: "What are the properties of the ice, the water, and the steam?" Explain the ice is a solid and has a definite shape and a definite volume; the water is a liquid and has no definite shape but it does have a definite volume; the steam is a gas and has no definite shape and no definite volume.

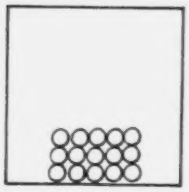
   ***NOTE TO TEACHER:** Refer to Kinetic Molecular Theory: All matter is composed of tiny particles which are in constant motion. At any given temperature, all substances, whether solid, liquid, or gas have the same average kinetic energy. Thus, depending on the mass of the particles and the inter- and intra-molecular forces exerted on them, the particles making up different substances will have different average velocities, even though they are at the same temperature. A solid has a definite shape because its molecules move very slowly, and because there are many attractive forces which keep them close together. Kinetic energy in solids is manifested mostly in the form of rotational and vibrational kinetic energy, with very little translational kinetic energy. A liquid takes the shape of its container because its particles move faster and are somewhat further apart than for a solid at the same temperature. Ice is a notable exception to this rule. As water solidifies, the molecules move further apart in a crystalline arrangement. A gas takes the shape of the entire container because the forces of attraction are much weaker than for the other two phases, so the molecules can travel very fast and remain very far apart. Translational kinetic energy is highest for gases. [Please note that this material is presented only as background information for the teacher, and is not intended to be given to the students in this course.]



GAS



LIQUID



SOLID

2. Elicit that the ice, the water, and the steam are all composed of the same molecules.

3. Have the students compare the relative distances among the molecules of the ice, the water, and the steam.

4. Ask the students to generalize about the RELATIVE DISTANCES among the molecules of SOLIDS, LIQUIDS, and GASES. Elicit that the molecules or atoms of a liquid are farther apart than those of a solid; the molecules of a gas are relatively far apart.

SUMMARY

1. "Compare the properties of solids, liquids, and gases."

2. "How does adding or removing energy affect molecular motion?"

3. "How would adding or removing energy affect the state of a substance?"

## Lesson 4:· WHAT ARE THE TYPES OF MATTER?

AIM: "What is the difference between a mixture and a compound?"

PERFORMANCE OBJECTIVES: The students will be able to:

- distinguish between elements, compounds, mixtures.
- demonstrate one technique by which a compound can be broken down into its elements.

MATERIALS: Hoffman apparatus, sulfuric acid, test tubes, wood splints, matches, iron filings, sulfur, test tube holder, test tube rack, magnet.

MOTIVATION: Set up the Hoffman apparatus. Ask class: "What is taking place?"

DEVELOPMENT

1. Demonstrate the Hoffman apparatus. Allow students to help in the test for oxygen and hydrogen. To test for oxygen and hydrogen:

    a. Tap off each gas into a small test tube. Test the gas of greater volume with a burning splint. Have the students observe the "POP." Hydrogen is present.

    b. Test the other gas with a glowing splint. Call the attention of the class to the fact that the splint bursts into flame and thus identifies the gas as oxygen.

2. Ask: "What does this tell us about water?" Explain that water is made up of the gases hydrogen and oxygen.

3. Ask: "How is water different from hydrogen or oxygen?" Identify hydrogen and oxygen as elements and water as a compound. Elicit definition of an element: a substance made up only of atoms of the same kind. An element cannot be broken down into simpler substances without changing its properties. Elicit definition of a compound: a substance made up of two or more elements. The properties of a compound are different from the elements which make it up. A compound can be broken down into its elements.

4. Mix iron filings and sulfur together. Ask: "Why is this called a mixture rather than a compound?" Have a student use a magnet to separate the iron from the sulfur. Define a mixture as two or more substances which are not chemically combined and can be easily separated by physical means.

    Elicit other examples of mixtures (i.e.: air, salt water, vegetable soup, milk).

5. Ask: "How can we make a compound from iron and sulfur?" Heat the mixture of iron and sulfur to form iron oxide. Ask: "How can we show that this is not a mixture, but a compound?" Show the properties of the elements have changed by demonstrating that using the magnet will no longer separate the iron filings from the sulfur.

## SUMMARY

1. "Although water consists of hydrogen (which explodes) and oxygen (which supports burning), explain why water is used to put out fires."

2. "If water is 1/3 oxygen and air is only 1/5 oxygen, how is it possible for a person to drown?"

3. "How can sodium (a dangerous metal) and chlorine (a dangerous gas) be regularly eaten with foods?"

## Lesson 5: HOW DO ELEMENTS COMBINE?

AIM: "How does burning affect iron's mass?"

PERFORMANCE OBJECTIVES: The students will be able to:

- explain that iron's mass will increase when burned because the iron combines with oxygen to form the compound iron oxide.
- formulate hypotheses to solve a problem.
- execute specific psychomotor laboratory skills, such as using tongs, burners, balances.
- interpret data and draw conclusions based upon the data.
- evaluate experimental design and results.

MATERIALS: See Laboratory Worksheet 2.2, rusty nail, pure iron.

MOTIVATION: Show a rusty nail (or any other iron compound) to the class. Show pure iron or steel. Why is it difficult to recognize the iron in the compound?

### DEVELOPMENT

- Guide class through Laboratory Worksheet 2.2.

### SUMMARY

- See Laboratory Worksheet 2.2.

# LABORATORY WORKSHEET 2.2

NAME__________________________ CLASS______________DATE ____________________

PROBLEM: How does burning affect iron's mass?

MATERIALS: Steel wool, forceps, alcohol lamp, ceramic pad (do not use asbestos), iron filings, Petri dish (half), safety glasses or goggles, triple beam balance.

INTRODUCTION: Elements are the simplest forms of matter. They are made up of atoms which are all the same. They cannot be broken down into simpler substances or changed chemically into anything else. Yet, in nature, most elements are rarely seen alone. They occur in combined forms known as compounds.

## PROCEDURE

1. Examine the ball of steel wool. Record its properties on the chart attached to this worksheet.

2. Record the MASS of the steel wool on your chart. Obtain the MASS by placing the CERAMIC PAD on the balance and the steel wool on top of the pad. YOU MUST MASS BOTH TOGETHER.

3. Following the directions below, BURN your steel wool ball:

   a. Carefully light your alcohol lamp. [Caution: Follow your teacher's instructions.]

   b. Place the ceramic pad alongside the lamp.

   c. Hold the steel wool with the forceps. Place it in the lamp's flame, holding it close to the ceramic pad. [Do not tilt the alcohol lamp to heat the steel wool!]

   d. Once the steel wool has begun to glow, remove it from the flame and put the cover on the burner, holding the steel wool over the ceramic pad. Blow GENTLY until the glow disappears.

4. Observe how the burning process has CHANGED the physical properties of the steel wool. Add these observations to your chart.

5. Remass your steel wool ball and ceramic pad together. (Remember to keep it on the ceramic pad at all times. DO NOT TOUCH THE STEEL WOOL. IT MAY BE HOT AND STILL SMOLDERING.) Record the new mass of the steel wool on your chart.

## LABORATORY WORKSHEET 2.2 (continued)

NAME ______________________________ Page 2

6. Interpret the results of burning the steel wool.

| | STEEL WOOL AND PAD BEFORE BURNING | STEEL WOOL AND PAD AFTER BURNING |
|---|---|---|
| PHYSICAL PROPERTIES (Appearance only) | | |
| MASS | | |

A. How has the process of burning "CHANGED" the steel wool?

_______________________________________________

B. Why is the mass of the steel wool different before and after burning?

_______________________________________________

_______________________________________________

C. Write a WORD EQUATION to describe the "burning" process.

_______________________________________________

_______________________________________________

D. Why is burning often referred to as OXIDATION?

_______________________________________________

_______________________________________________

_______________________________________________

E. What evidence do you have that the change in the steel wool is a "permanent" change?

_______________________________________________

_______________________________________________

# LABORATORY WORKSHEET 2.2 (continued)

NAME ______________________________ Page 3

F. The substance that has formed is called a compound.

a. What would you name this compound? ______________________________

b. Define COMPOUND. ______________________________

______________________________

SUMMARY/HOMEWORK

1. Predict what would occur if the elements sodium and chlorine were placed in a test tube and heated.
2. Write a word equation that summarizes your prediction.
3. Compounds form as the result of chemical changes. Define CHEMICAL CHANGE.

## Lesson 6: WHAT IS THE STRUCTURE OF THE ATOM?

AIM: "What theories can be proposed to explain the attraction and repulsion of non-magnetic materials?"

PERFORMANCE OBJECTIVES: The students will be able to:

- create a model to explain observed phenomena.
- cite evidence that matter is composed of invisible particles called atoms.
- cite evidence that atoms have negatively charged particles called electrons, positively charged particles called protons, and uncharged particles called neutrons.

MATERIALS: Cat fur, rubber rod, silk, plastic rod, pith balls, string, ring stand.

MOTIVATION: Run a narrow stream of water from a burette tube or from the laboratory faucet. Rub the rubber rod vigorously with cat's fur. Bring the rubber rod close to the stream of flowing water, but do NOT touch the water with the rubber rod. The water will be attracted by the rubber rod. Gently move the rubber rod around the stream of water. The water will appear to "dance."

DEVELOPMENT

1. Ask the students to give an explanation for what they observed.
2. Rub the rod on the cat's fur and demonstrate the attraction of suspended pith balls to the rubber rod.

   Ask students to record their observations.
3. Touch both pith balls with the rubber rod to demonstrate to the class that the PITH BALLS WILL REPEL EACH OTHER when BOTH are touched by the rubber rod.
4. Repeat, using a plastic rod and silk.
5. Have students describe what they observed.
6. Have students hypothesize to explain what they observed and then discuss the hypotheses.
7. Guide students to conclude that matter is electrical in nature, as illustrated by the "dancing" water and the pith balls.
8. Touch one pith ball with a charged rubber rod, and the other pith ball with the glass rod. The pith balls should attract each other.

9. Guide the students to conclude that matter is composed of oppositely charged particles.

   a. "What do you conclude, based upon the fact that the water was attracted by the rubber rod?" Elicit that the charged rubber rod attracted water molecules.

   b. "Devise your own theory to explain why the pith balls were repelled when both were touched with the rubber rod." Elicit they acquired the same electrical charge.

   c. "Devise your own theory to explain why one pith ball, when touched with the rubber rod, attracted the other pith ball, which was touched with the plastic." Elicit that the two pith balls were oppositely charged.

***NOTE TO TEACHER:** Pull the rubber rod strongly and just once through the fur. It becomes charged negatively while the fur takes a positive charge. In other words, electrons removed from the fur are transferred to the rod.

A glass rod may be substituted for the plastic. However, it is very difficult to give glass an electric charge unless the glass is very dry and there is little humidity in the room. Plastic, such as lucite, is very easy to charge, even on damp days.

Silk should have the plastic rod pulled through it. The plastic rod becomes positively charged, while the silk becomes negatively charged. Here, electrons are removed from the plastic rod and transferred to the silk.

We believe that only the negatively charged electrons transfer and the positively charged protons remain in the nuclei of atoms.

10. Ask: "How can we account for the fact that matter is composed of electrons and protons but has a net electric charge of zero?"

    a. "If negative charges are on the outside of the atom, why do we assume that there must be positive charges inside?"

    b. "Why must the number of positive charges be equal to the number of negative charges in a neutral atom?"

    c. Tell students that electrons are particles with negative charges and protons are particles with positive charges.

    d. Explain that the center of the atom also contains particles that have no electric charge, called neutrons. A neutron sometimes disintegrates and forms a proton and an electron.

11. To illustrate how the atomic particles compare with one another, a chart such as the following can be developed on the chalkboard:

| PARTICLE | CHARGE | MASS | LOCATION |
|---|---|---|---|
| Electron | negative | negligible | outside of center of atom |
| Proton | positive | one unit (about 2000 times mass of electron) | center of the atom |
| Neutron | none | almost equal to a proton | center of the atom |

SUMMARY

1. "Why did scientists originally think of an atom as resembling a small solar system?"

2. "Explain how an atom can be electrically neutral when it is composed of positive and negative charges."

FOR FURTHER THOUGHT

. "What are some other subatomic particles?"

## Lesson 7: ATOMIC STRUCTURE

AIM: "In what way are all atoms alike?"

[OPTIONAL]

PERFORMANCE OBJECTIVES: The students will be able to:

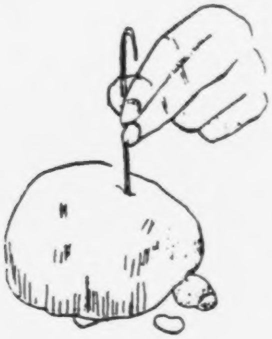
- state that an atom is made up of an electron cloud and a more solid nucleus.
- construct a model of an atom.

MATERIALS: Laboratory Worksheet 2.3 (Mini-Lab), atomic model.

MOTIVATION: "Let's look at an atomic model."

DEVELOPMENT

1. Distribute Laboratory Worksheet 2.3 (Mini-Lab).
   HINT TO THE TEACHER: Use modeling clay to make balls 2-3 cm in diameter. Each ball should contain a small hard object. To probe, use regular paper clips, straightened out except for one loop. (See diagram.)



2. Have students compare outer and inner parts of an atom.

3. Discuss mass of the atom. Ask: "Why can we assume that the additional particles (neutrons) have no charge?"

SUMMARY

- See Laboratory Worksheet 2.3 (Mini-Lab).

# LABORATORY WORKSHEET 2.3

## *MINI—LAB*

NAME______________________________ CLASS______________DATE____________________

**PROBLEM:** How do atoms compare to each other?

**MATERIALS:** Clay "atom," paper clip probe.

**INTRODUCTION:** It is hard to imagine how small an atom is. More than one million of them, side by side, would only be as thick as this page. By working with a model designed to represent an atom, scientists discovered that atoms are made up of even smaller particles. Today, you will "probe" into a clay form of an atom model you design to see what you can learn about these particles.

**PROCEDURE**

1. Study the OUTER region of the atom. Examine it carefully with your finger tips. This area is often referred to as the ELECTRON CLOUD.

   Scientists shoot atomic particles at atoms to study atomic structure. In place of atomic particles you will use a probe made from a paper clip.

2. Use the paper clip "probe" to examine the INNER atom. Push the probe into or through the clay ten times. Probe with care.

   a. How is the center of the atom different from the outer area?

   b. Draw a "sketch" of the clay atom showing its INNER AND OUTER structure.

   c. Now cut open the clay atom and see how accurate your model was. Draw a "sketch" of the ACTUAL structure of your clay atom.

# LABORATORY WORKSHEET 2.3 (continued)

NAME ______________________________

d. What has the probe told you about the atom?

________________________________________________________________

________________________________________________________________

3. The INNER area of the atom is called the NUCLEUS.

   a. How does the nucleus differ from the electron cloud?

   ________________________________________________________________

   b. How does this difference explain why most of the motion of an atom occurs in the electron cloud?

   ________________________________________________________________

SUMMARY/HOMEWORK

1. Explain why the number of electrons and the number of protons in an atom are equal to each other.

   (Check your textbook for the following:)

2. How is the ATOMIC NUMBER of an atom determined?

3. How is the ATOMIC MASS of an atom determined?

FOR FURTHER THOUGHT

. If electrons are negative, and protons are positive, why aren't the electrons attracted to the nucleus and fall into it?

# Lesson 8: HOW DO ATOMS DIFFER?

AIM: "How can we discover the relative activity of metallic elements?"

PERFORMANCE OBJECTIVES: The students will be able to:

- state that properties of elements differ because atoms differ.
- relate the properties of atoms to the number of electrons and electron shells.
- identify a problem suggested by a specific situation.
- reason inductively and deductively.

MATERIALS: Samples of K, Na, Mg, Zn, and Fe, plus five beakers of water. There also could be an atomic model on display.

MOTIVATION: Display samples of iron, zinc, magnesium, sodium, and potassium. Carefully drop each sample, beginning with iron, into a separate beaker of water. (CAUTION: Be certain to use SMALL pieces of potassium and sodium - about the size of a pea - and large quantities of water. Wear safety glasses and erect a clear plastic shield between the apparatus and the students.)

DEVELOPMENT

1. Have the students describe what they observed. The students should conclude that potassium and sodium are highly active, and are more active than magnesium, zinc, and iron.

2. Guide the students to conclude that potassium and sodium atoms must be different from the atoms of magnesium, zinc, and iron.

3. Have the students compare the probable properties of potassium and sodium atoms with the properties of magnesium, zinc, and iron atoms.

4. Ask: "Since potassium and sodium react violently with water, but magnesium, zinc, and iron do not, what conclusions can you draw about their atomic structures?" Elicit that potassium and sodium have atoms that are similar to each other, but are different from those of magnesium, zinc and iron.

5. Tell the students that by experiments similar to those we have done in class, scientists have created ever-changing models of the atom. As new information becomes available, the atomic model must be modified, even today.

6. Have students write a paragraph, "How are all atoms alike?" and have them read the paragraphs aloud.

7. Ask: "How do atoms differ?"

8. Have students examine the chart on the "Special Activity" sheet accompanying this lesson, and ask the following questions: "How are the atoms shown on the sheet alike?" "How do they differ?"

9. Have the students discuss the atoms' electronic configurations. Briefly explain how the distance of electrons from the nucleus in the last or outermost energy level relates to electronic attractions between the electrons and the nuclear protons.

10. Given the mass of an atomic nucleus and the mass of the protons, explain how to determine the number of neutrons in an atom.

11. Draw diagrams of potassium and sodium on the chalkboard.

    a. Ask: "How are potassium and sodium atoms similar?" Elicit each has one electron in its outermost energy level.

    b. Ask: "How are potassium and sodium atoms different?" Elicit each has a different number of electrons, and a different number of energy levels.

12. Compare potassium's and sodium's activity, explaining that potassium is more active. Ask the students to explain why potassium is more active. Elicit that potassium's outermost energy level is farther from the nucleus than is sodium's outermost energy level. Therefore, the potassium electron is less strongly bound and it is freer to move and combine with other materials.

13. Ask: "What do you conclude about magnesium, zinc and iron atoms?" Elicit that they are similar. They all have two electrons in the outermost energy level.

SUMMARY

1. "How do atoms differ?"

2. "How do differences in atomic structure help to explain the differences in the properties of elements?"

**NOTE:** Students should not be required to construct the electron diagrams for elements beyond argon - atomic number 18.

## *SPECIAL ACTIVITY SHEET*

# HOW DO ATOMS DIFFER?

NAME______________________________ CLASS____________ DATE____________________

PROBLEM: How do atoms differ?

INTRODUCTION: If all matter is composed of similar atoms, how can we explain the many different types of matter that we find around us? How do we explain the variety of properties (color, texture, density, magnetism, etc.) that enable us to recognize the different materials that we find in our environment? How do we account for the various types of behavior we see among the elements? (Some are explosive, some quiet, some will melt easily, some will combine easily with others, etc.) We must conclude that these result from differences among the atoms themselves. Today you will study a selected group of atoms to determine some of these differences and how they affect matter.

PROCEDURE

- Study the chart you were given with this Special Activity Sheet, and answer the following questions.

1. Each of the types of atoms shown on the chart represents a different ELEMENT. In your own words, write a definition of ELEMENT.

2. List some common elements with which you are familiar. DO NOT LIST THE ELEMENTS SHOWN ON THIS CHART.

3. Scientists have found 106 different elements as of 1982. How does the atomic structure of atomic number 105 differ from that of atomic number 106?

NAME ______________________

EXAMINE THE ATOMS ON YOUR CHART

4. Make a list of those elements shown on the chart that you think would be most ACTIVE. (Remember the demonstrations with potassium and sodium at the beginning of lesson.)

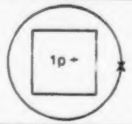
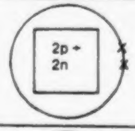
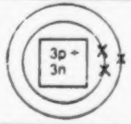
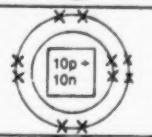
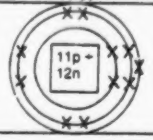
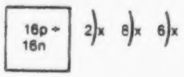
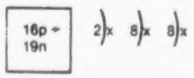
5. State at least one REASON why you think that the atoms that you have listed above are active elements.

6. Each ring of electrons that surrounds the nucleus represents an energy level. What is the maximum number of electrons in each of the following energy levels?

| Energy Level | Letter | Maximum Electron Number |
|---|---|---|
| 1 | K | |
| 2 | L | |
| 3 | M | |
| 4 | N | |

(continued)

NAME ______________________________

| TYPE OF ATOM | ATOMIC NO. | ATOMIC WT. | ATOMIC PICTURE (X=electron) |
|---|---|---|---|
| Hydrogen | 1 | 1 |  Gas molecule is $H_2$<br>Explosive |
| Helium | 2 | 4 |  Gas<br>Does not burn |
| Lithium | 3 | 7 |  Metal |
| Neon | 10 | 20 |  Gas<br>Does not burn |
| Sodium | 11 | 23 |  Metal<br>Can explode |
| Sulfur | 16 | 32 |  Nonmetal<br>Yellow |
| Argon | 18 | 37 |  Gas<br>Does not burn |

SUMMARY/HOMEWORK

1. How does the structure of atoms differ?

2. How do differences in atomic structure help to explain the differences in the properties of elements?

FOR FURTHER THOUGHT

Draw atomic pictures for:

| Fluorine | Oxygen | Magnesium |
|---|---|---|
| Atomic No. 9 | Atomic No. 8 | Atomic No. 12 |
| Atomic Mass=19 units | Atomic Mass=16 units | Atomic Mass=24 units |

## Lesson 9: HOW CAN WE "ORGANIZE" THE ELEMENTS?

AIM: "Why are elements arranged in groups"

PERFORMANCE OBJECTIVES: The students will be able to:

. design a Periodic Table from their knowledge of the elements.
. state that the elements can be best arranged according to atomic number.
. state that the official table on which the elements are organized is called the Periodic Table of the Elements.
. explain the use of the term "periodic."

MATERIALS: Samples of lithium, sodium, potassium, magnesium and calcium, as well as others that are available; Periodic Table; element cards that include the names of the sample elements available; calendar.

MOTIVATION: Display array of elements. Ask: "How can we arrange these elements?"

DEVELOPMENT

1. Ask: "Why is an alphabetical listing the easiest way to put things in order?"
    a. Distribute sample element cards. Ask class to arrange them in some kind of order.
    b. Have students use alphabetical arrangement.
    c. "Why is this method insufficient when it comes to the elements?"

2. Allow students, in groups, to discuss other ways of arranging elements. Have each group prepare a list of alternatives and write these on board.

3. Ask: "Which of these seems to make the most sense?"

4. Ask: "Why is it better to arrange elements by atomic number rather than atomic mass?" (Chemical differences show up better.)

5. a. Display calendar. Ask: "How is separation made here? Why is this a natural separation? Why can we call this the Periodic Calendar?"
    b. Have students determine what repeating phenomenon appears among the atoms of the elements. Refer to chart if necessary.
    c. Ask: "How can we use electrons in the outer shell to construct the chart? Why can we call this the 'Periodic' Chart?"

6. Have students study the Periodic Table. "How can this table help us learn more about the elements? What kind of information does this table give us about the elements? How can this table be used to predict properties of the elements?"

## SUMMARY

1. "Why is it necessary to organize the elements?"
2. "Why does using atomic numbers make good sense?"
3. "Why is the table of elements called the Periodic Table?"
4. "What do we mean by the term periodic?"

## FOR FURTHER THOUGHT

- "How were elements first arranged on the Periodic Table? What contribution did Dmitri Mendeleyev make to the Periodic Table?"

# ADDITIONAL IN-CLASSROOM ACTIVITY

1. Write a report on the work of Niels Bohr and his model of the atom.
2. Name five mixtures found at home. How do you know they are mixtures?
3. Name five compounds found at home. How do you know they are compounds?
4. Identify the following as solid, liquid, or gas. What compound are we identifying?

    steam
    snow
    iceberg
    rain
    cloud
    hail

5. What is meant by "man-made" elements? Using the Periodic Chart, name ten man-made elements.

ESSENTIAL VOCABULARY

1. matter
2. molecule
3. substance
4. atom
5. arrangement
6. released
7. state (of matter)
8. construct
9. evidence
10. element
11. metal
12. nonmetal
13. alchemist
14. Periodic Table
15. bonding
16. constant
17. combine
18. compound
19. predict
20. physical change
21. chemical change
22. inert
23. electrolysis
24. decomposition

# Table of Radioactive Isotopes

Ac 227(22y)$\beta^-$,$\alpha$
Ag 110(24s)$\beta^-$,$\gamma$
111(7.5d)$\beta^-$,$\gamma$
Am 241(458y)$\alpha$,$\gamma$,$e^-$
242(16.0h)$\beta^-$,K,$\alpha$,$\gamma$
243(8000y)$\alpha$,$\gamma$
As 76(26.7h)$\beta^-$,$\gamma$
77(39h)$\beta^-$,$\gamma$
At 210(8.3h)K,$\alpha$,$\gamma$
211(7.2h)K,$\alpha$,$\gamma$
Au 198(2.69d)$\beta^-$,$\gamma$
Ba 131(12d)K,$\gamma$
133(7.2y)K,$\gamma$,$e^-$
Bi 210(5d)$\beta^-$,$\alpha$
Bk 245(4.9d)K,$\alpha$,$\gamma$
249(314d)$\beta^-$,$\alpha$,SF
Br 82(36h)$\beta^-$,$\gamma$
C 14(5700y)$\beta^-$
Ca 41(8×10$^4$y)K
45(165d)$\beta^-$
47(4.5d)$\beta^-$,$\gamma$

Cd 115(43d)$\beta^-$,$\gamma$
Ce 141(32d)$\beta^-$,$\gamma$
143(33h)$\beta^-$,$\gamma$
144(285d)$\beta^-$,$\gamma$
Cf 246(35.7h)$\alpha$,$\gamma$,SF
249(360y)$\alpha$,$\gamma$,SF
251(800y)$\alpha$
Cl 36(3×10$^5$y)$\beta^-$
Cm 243(35y)$\alpha$,$\gamma$
245(9300y)$\alpha$,$\gamma$
247(10$^7$y)
Co 58(71d)K,$\beta^+$,$\gamma$
60(5.27y)$\beta^-$,$\gamma$
Cr 51(27d)K,$\gamma$
Cs 134(2.0y)$\beta^-$,$\gamma$
135(3×10$^6$y)$\beta^-$
137(30y)$\beta^-$,$\gamma$
Cu 64(12.8h)K,$\beta^-$,$\beta^+$,$\gamma$
Es 253(20d)$\alpha$,$\gamma$,SF
254(1y)$\alpha$,SF
Eu 154(16y)$\beta^-$,$\gamma$
155(1.8y)$\beta^-$,$\gamma$

Fe 55(2.6y)K
59(45d)$\beta^-$,$\gamma$
Fm 255(20h)$\alpha$
Fr 223(22m)$\beta^-$,$\gamma$,$\alpha$
Ga 72(14.1h)$\beta^-$,$\gamma$
Gd 153(236d)K,$\gamma$,$e^-$
159(18h)$\beta^-$,$\gamma$
Ge 71(11d)K
H 3(12.3y)$\beta^-$
Hf 181(45d)$\beta^-$,$\gamma$,$e^-$
Hg 197(65h)K,$\gamma$,$e^-$
203(47d)$\beta^-$,$\gamma$,$e^-$
Ho 166(27.3h)$\beta^-$,$\gamma$
I 129(10$^7$y)$\beta^-$,$\gamma$,$e^-$
131(8.05d)$\beta^-$,$\gamma$
In 114(50d)$\gamma$
Ir 192(74.4d)$\beta^-$,$\gamma$
K 40(10$^9$y)$\beta^-$,K,$\gamma$
42(12.4h)$\beta^-$,$\gamma$

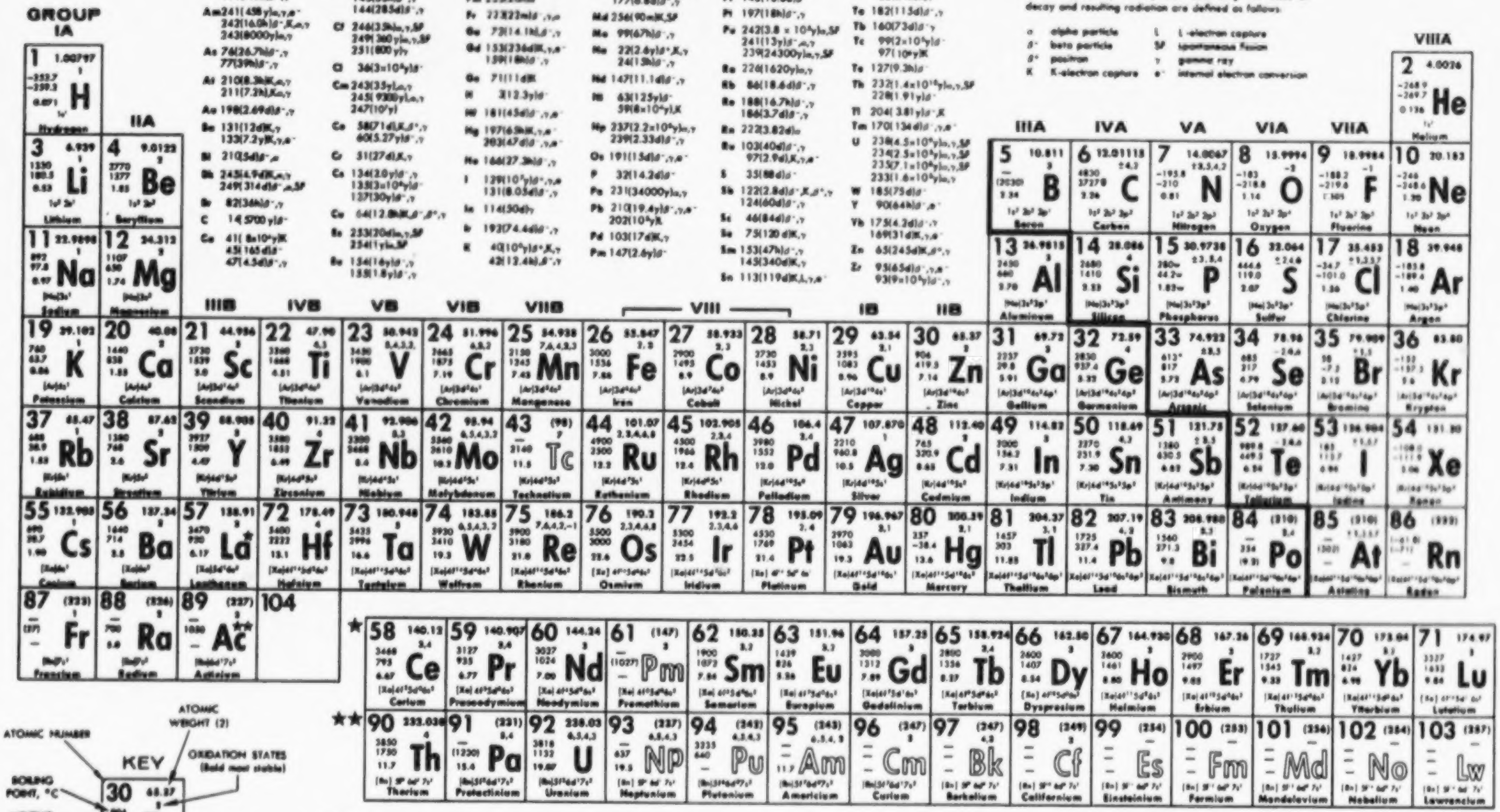
La 140(40.2h)$\beta^-$,$\gamma$
Lu 176(10$^{10}$y)$\beta^-$,K,$\gamma$
177(6.8d)$\beta^-$,$\gamma$
Md 256(90m)K,SF
Mo 99(67h)$\beta^-$,$\gamma$
Na 22(2.6y)$\beta^+$,K,$\gamma$
24(15h)$\beta^-$,$\gamma$
Nd 147(11.1d)$\beta^-$,$\gamma$
Ni 63(125y)$\beta^-$
59(8×10$^4$y)K
Np 237(2.2×10$^6$y)$\alpha$,$\gamma$
239(2.33d)$\beta^-$,$\gamma$
Os 191(15d)$\beta^-$,$\gamma$,$e^-$
P 32(14.2d)$\beta^-$
Pa 231(34000y)$\alpha$,$\gamma$
Pb 210(19.4y)$\beta^-$,$\gamma$,$e^-$
202(10$^5$y)K
Pd 103(17d)K,$\gamma$
Pm 147(2.6y)$\beta^-$

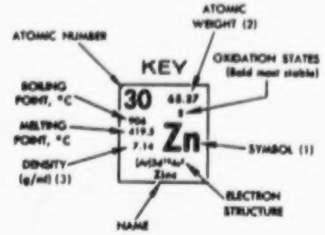
Po 210(138.4d)$\alpha$,$\gamma$
209(103y)$\alpha$,K,$\gamma$
Pr 143(13.8d)$\beta^-$
Pt 197(18h)$\beta^-$,$\gamma$
Pu 242(3.8 × 10$^5$y)$\alpha$,SF
241(13y)$\beta^-$,$\alpha$,$\gamma$
239(24300y)$\alpha$,$\gamma$,SF
Ra 226(1620y)$\alpha$,$\gamma$
Rb 86(18.6d)$\beta^-$,$\gamma$
Re 188(16.7h)$\beta^-$,$\gamma$
186(3.7d)$\beta^-$,$\gamma$
Rn 222(3.82d)$\alpha$
Ru 103(40d)$\beta^-$,$\gamma$
97(2.9d)K,$\gamma$,$e^-$
S 35(88d)$\beta^-$
Sb 122(2.8d)$\beta^-$,K,$\beta^+$,$\gamma$
124(60d)$\beta^-$,$\gamma$
Sc 46(84d)$\beta^-$,$\gamma$
Se 75(120d)K,$\gamma$
Sm 153(47h)$\beta^-$,$\gamma$
145(340d)K,$\gamma$
Sn 113(119d)K,L,$\gamma$,$e^-$

Sr 90(28y)$\beta^-$
89(51d)$\beta^-$,$\gamma$
85(64d)K,$\gamma$
Ta 182(115d)$\beta^-$,$\gamma$
Tb 160(73d)$\beta^-$,$\gamma$
Tc 99(2×10$^5$y)$\beta^-$
97(10$^6$y)K
Te 127(9.3h)$\beta^-$
Th 232(1.4×10$^{10}$y)$\alpha$,$\gamma$,SF
228(1.91y)$\alpha$
Tl 204(3.81y)$\beta^-$,K
Tm 170(134d)$\beta^-$,$\gamma$,$e^-$
U 238(4.5×10$^9$y)$\alpha$,$\gamma$,SF
234(2.5×10$^5$y)$\alpha$,$\gamma$,SF
235(7.1×10$^8$y)$\alpha$,$\gamma$,SF
233(1.6×10$^5$y)$\alpha$,$\gamma$
W 185(75d)$\beta^-$
Y 90(64h)$\beta^-$,$e^-$
Yb 175(4.2d)$\beta^-$,$\gamma$
169(31d)K,$\gamma$,$e^-$
Zn 65(245d)K,$\beta^+$,$\gamma$
Zr 95(65d)$\beta^-$,$\gamma$,$e^-$
93(9×10$^5$y)$\beta^-$,$\gamma$

Naturally occurring radioactive isotopes are indicated by a blue mass number. Half lives are in parentheses where s, m, h, d and y stand for seconds, minutes, hours, days and years respectively. The symbols describing the mode of decay and resulting radiation are defined as follows.

| | | | |
|---|---|---|---|
| $\alpha$ | alpha particle | L | L-electron capture |
| $\beta^-$ | beta particle | SF | spontaneous fission |
| $\beta^+$ | positron | $\gamma$ | gamma ray |
| K | K-electron capture | $e^-$ | internal electron conversion |


GROUP IA
IIA
IIIB
IVB
VB
VIB
VIIB
VIII
IB
IIB
IIIA
IVA
VA
VIA
VIIA
VIIIA
1 1.00797 H Hydrogen
2 4.0026 He Helium
3 6.939 Li Lithium
4 9.0122 Be Beryllium
5 10.811 B Boron
6 12.01115 C Carbon
7 14.0067 N Nitrogen
8 15.9994 O Oxygen
9 18.9984 F Fluorine
10 20.183 Ne Neon
11 22.9898 Na Sodium
12 24.312 Mg Magnesium
13 26.9815 Al Aluminum
14 28.086 Si Silicon
15 30.9738 P Phosphorus
16 32.064 S Sulfur
17 35.453 Cl Chlorine
18 39.948 Ar Argon
19 39.102 K Potassium
20 40.08 Ca Calcium
21 44.956 Sc Scandium
22 47.90 Ti Titanium
23 50.942 V Vanadium
24 51.996 Cr Chromium
25 54.938 Mn Manganese
26 55.847 Fe Iron
27 58.933 Co Cobalt
28 58.71 Ni Nickel
29 63.54 Cu Copper
30 65.37 Zn Zinc
31 69.72 Ga Gallium
32 72.59 Ge Germanium
33 74.922 As Arsenic
34 78.96 Se Selenium
35 79.909 Br Bromine
36 83.80 Kr Krypton
37 85.47 Rb Rubidium
38 87.62 Sr Strontium
39 88.905 Y Yttrium
40 91.22 Zr Zirconium
41 92.906 Nb Niobium
42 95.94 Mo Molybdenum
43 (99) Tc Technetium
44 101.07 Ru Ruthenium
45 102.905 Rh Rhodium
46 106.4 Pd Palladium
47 107.870 Ag Silver
48 112.40 Cd Cadmium
49 114.82 In Indium
50 118.69 Sn Tin
51 121.75 Sb Antimony
52 127.60 Te Tellurium
53 126.9044 I Iodine
54 131.30 Xe Xenon
55 132.905 Cs Cesium
56 137.34 Ba Barium
57 138.91 La Lanthanum
72 178.49 Hf Hafnium
73 180.948 Ta Tantalum
74 183.85 W Wolfram
75 186.2 Re Rhenium
76 190.2 Os Osmium
77 192.2 Ir Iridium
78 195.09 Pt Platinum
79 196.967 Au Gold
80 200.59 Hg Mercury
81 204.37 Tl Thallium
82 207.19 Pb Lead
83 208.980 Bi Bismuth
84 (210) Po Polonium
85 (210) At Astatine
86 (222) Rn Radon
87 (223) Fr Francium
88 (226) Ra Radium
89 (227) Ac Actinium
104
58 140.12 Ce Cerium
59 140.907 Pr Praseodymium
60 144.24 Nd Neodymium
61 (147) Pm Promethium
62 150.35 Sm Samarium
63 151.96 Eu Europium
64 157.25 Gd Gadolinium
65 158.924 Tb Terbium
66 162.50 Dy Dysprosium
67 164.930 Ho Holmium
68 167.26 Er Erbium
69 168.934 Tm Thulium
70 173.04 Yb Ytterbium
71 174.97 Lu Lutetium
90 232.038 Th Thorium
91 (231) Pa Protactinium
92 238.03 U Uranium
93 (237) Np Neptunium
94 (242) Pu Plutonium
95 (243) Am Americium
96 (247) Cm Curium
97 (247) Bk Berkelium
98 (249) Cf Californium
99 (254) Es Einsteinium
100 (253) Fm Fermium
101 (256) Md Mendelevium
102 (254) No Nobelium
103 (257) Lw Lawrencium


KEY
ATOMIC NUMBER
ATOMIC WEIGHT (2)
OXIDATION STATES (Bold most stable)
BOILING POINT, °C
MELTING POINT, °C
DENSITY (g/ml) (3)
SYMBOL (1)
ELECTRON STRUCTURE
NAME
30
65.37
2
906
419.5
7.14
Zn
Zinc

NOTES:

(1) Black — solid.
Red — gas.
Blue — liquid.
Outline — synthetically prepared.

(2) Based upon carbon – 12. ( ) indicates most stable or best known isotope.

(3) Values for gaseous elements are for liquids at the boiling point.

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periodic table of the elements

This chart accompanies Lesson 9 on the Periodic Table. The teacher may wish to duplicate this material and cut apart the 18 elements so students can try different ways of arranging them in a periodic chart.

### Hydrogen

Atomic number 1
Atomic mass 1

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 1 |

### Helium

Atomic number 2
Atomic mass 4

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 2 |

### Lithium

Atomic number 3
Atomic mass 7

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 2 |
| 2 | 1 |

### Beryllium

Atomic number 4
Atomic mass 9

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 2 |
| 2 | 2 |

### Boron

Atomic number 5
Atomic mass 11

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 2 |
| 2 | 3 |

### Carbon

Atomic number 6
Atomic mass 12

Electron Shells:

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 4 |

### Nitrogen

Atomic number 7
Atomic mass 14

Electron Shells:

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 5 |

### Oxygen

Atomic number 8
Atomic mass 16

Electron Shells:

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 6 |

### Fluorine

Atomic number 9
Atomic mass 19

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 2 |
| 2 | 7 |

**Neon**

Atomic number 10
Atomic mass 20

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |

**Sodium**

Atomic number 11
Atomic mass 23

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 1 |

**Magnesium**

Atomic number 12
Atomic mass 24

Electron Shells:

| Shell | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 2 |

**Aluminum**

Atomic number 13
Atomic mass 27

Electron Shells:

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 3 |

**Silicon**

Atomic number 14
Atomic mass 28

Electron Shells:

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 4 |

**Phosphorus**

Atomic number 15
Atomic mass 31

Electron Shells:

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 5 |

**Sulfur**

Atomic number 16
Atomic mass 32

Electron Shells:

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 6 |

**Chlorine**

Atomic number 17
Atomic mass 35

Electron Shells

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 7 |

**Argon**

Atomic number 18
Atomic mass 40

Electron Shells:

| Shells | Electrons |
|---|---|
| 1 | 2 |
| 2 | 8 |
| 3 | 8 |

## Lesson 10: HOW CAN WE EXPLAIN SOME DIFFERENCES AMONG ELEMENTS?

AIM: "How can we categorize samples of elements into a meaningful system?"

PERFORMANCE OBJECTIVES: The students will be able to:

- state that elements can be divided into either metal or nonmetal groups.
- compare some properties of metals and nonmetals.
- identify the noble gases as nonreactive under ordinary circumstances.

MATERIALS: Specific metallic elements, such as sodium, potassium, zinc, iron and copper; specific nonmetallic elements, such as sulfur, iodine, carbon, and bromine; variety of compounds; Periodic Table.

MOTIVATION: Display elements and have students divide them into related groups. Ask: "Why did you divide the elements the way you did?" Elicit that elements are usually divided into metals and nonmetals.

DEVELOPMENT

1. Have students suggest properties that would be found among the metallic elements. Elicit:

   a. Metals are identified by their luster (shine).

   b. Metals conduct heat and electricity.

   c. A metal that can be drawn into fine wire is said to be ductile.

   d. A metal that can be hammered and spread out without breaking is said to be malleable.

   "Where do we find the metallic elements on the Periodic Table?" Explain that metals are found to the left of the dark, step-like line. Approximately 75% of the elements are metals.

2. "What are some properties of nonmetallic elements?"

   Explain that nonmetals do not have the properties of metals. For example, sulfur has a dull luster and is a poor conductor of heat and electricity. Nonmetals are usually brittle, not ductile or malleable. Only about 20 elements are distinctly nonmetallic. Nonmetals are found to the right on the Periodic Table.

3. Have several compounds on display. Ask: "How do metals and nonmetals react with one another?" Elicit a general statement about compound formation. (A compound is usually made up of a metallic and a nonmetallic element.)

4. "In what way are the elements in group 0 different from the other elements?"

   Explain that all the elements in this family are gases under normal conditions. These gases are inert; they do not combine readily with other elements to form compounds. All the noble gases are found in small amounts in the atmosphere of the earth.

## SUMMARY

1. "From a knowledge of the Periodic Table and the fact that sodium reacts rapidly with water, tell how a scientist could predict how potassium will react with water."

2. "With the aid of the Periodic Table, compare and contrast the properties of magnesium and sulfur."

## Lesson 11: HOW DOES THE PERIODIC TABLE "DESCRIBE" THE ELEMENTS?

AIM: "How does the Periodic Table help us to describe sodium's properties?"

PERFORMANCE OBJECTIVES: The students will be able to:

- use the Periodic Table to obtain information that describes properties of elements.
- use the Periodic Table to predict properties of elements.
- state why universal symbols are used in the construction of the Periodic Table.

MATERIALS: Small Periodic Tables duplicated for students, large one for class to see.

MOTIVATION: Have the students look at the Periodic Table. Ask: "What are sodium's properties?"

DEVELOPMENT

***NOTE TO TEACHER:** The method for determining the symbols for the elements was taught in grade 7 (see 7th Grade Curriculum Guide, Chemistry, Lesson 7, pages 17-21). It may be necessary to review these rules now.

1. Refer to the Periodic Table and ask the students:

   a. "What information can we learn about sodium?" Elicit that sodium (Na) is in the Group IA.

   b. "How many electrons does sodium have in its outermost energy level?" Elicit one.

   c. "How many electrons do all the elements in Group IA have in the outermost energy level?" Elicit one.

   d. "Why would you expect all the elements in a particular group or family to have similar properties?" Explain that in a group or family of elements there are similarities, but not uniform, identical properties.

2. Briefly discuss the VIIA family called the halogens (salt formers). Explain to the class:

   a. "$F_2$ is a light yellow gas."

   b. "$Cl_2$ is a yellow green gas."

   c. "$Br_2$ is a dark brown liquid."

   d. "$I_2$ is a gray solid."

   e. "$At_2$ (astatine) is not found in nature. It is produced in nuclear reactors, and it is a black solid."

   f. "There are similarities, but each family member differs in color and ease of chemical activity."

3. Ask: "What do you mean by a period of elements?" Explain that a line going across the table is called a period. Point to the elements sodium, magnesium, aluminum, silicon, phosphorous, sulfur, chlorine, and argon. Ask: "How do the properties of these elements vary?" The elements on the left side are metals. As you move across the period from left to right, the elements are nonmetals. Ask "How do you know that sodium is a metallic element?"

4. Explain that some elements are not represented by the first letter of their name (i.e.: Iron -- Fe, Silver -- Ag.). Ask: "How can we explain this?" Review the use of Latin names in determining symbols for some of the elements.

5. Discuss the elements in Group 0 on the Periodic Table (inert gases or noble gases). Elicit that each element in Group 0 is at the end of a Period. Explain that this means that each element in Group 0 has a complete outermost energy level. Since these elements do NOT react, we can conclude that 2 electrons in the first energy level (helium), and 8 electrons in the other energy levels (neon, argon, krypton, xenon, and radon) are stable configurations. (Note to Teacher: In 1962 several of the "inert" gases were made to react with oxygen and fluorine. Thus, "inert" today means "react with difficulty" rather than "does not react.")

## SUMMARY

1. "Describe what is meant by a chemical family."

2. "How can the position of an element on the Periodic Table be of value to a scientist?"

## FOR FURTHER THOUGHT

1. "Assume that you have discovered a new element. The element turns out to be a poor conductor having a low melting point. Atoms of the element readily gain one electron. They also react with metals to form salts. In what chemical family would you place this element? Why?"

2. "Why do the noble gases not form chemical compounds easily?"

## ADDITIONAL IN-CLASSROOM ACTIVITY

## HOW CAN WE USE THE PERIODIC TABLE?

NAME________________________________ CLASS__________________________DATE______

DIRECTIONS: Using your Periodic Tables, fill in all the spaces in the chart.

| ELEMENT | SYMBOL | ATOMIC NUMBER | ATOMIC MASS | PERIOD | GROUP (FAMILY) | METAL, NONMETAL, OR NOBLE GAS |
|---|---|---|---|---|---|---|
| 1. Zinc | | | | | | |
| 2. Krypton | | | | | | |
| 3. Antimony | | | | | | |
| 4. Lead | | | | | | |
| 5. Iron | | | | | | |
| 6. | Br | | | | | |
| 7. | Sn | | | | | |
| 8. | He | | | | | |
| 9. | | 12 | | | | |
| 10. | | 53 | | | | |

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# Lesson 12: HOW DO ELEMENTS FORM COMPOUNDS?

AIM: "Why did the sodium lose its shine?"

PERFORMANCE OBJECTIVES: The students will be able to:

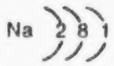
- identify metals as elements whose atoms donate electrons and thereby remain with completed outermost shells.
- identify nonmetals as elements whose atoms borrow electrons and thereby remain with completed outermost shells.
- relate the stability of an atom to the number of electrons in its outermost shell.
- state that chemical bonds result from the tendency of atoms to remain with complete outer energy levels.

MATERIALS: Periodic Table, sodium, scalpel or sharp knife, magnesium strip, tongs, burner.

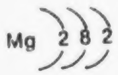
MOTIVATION: Carefully display a small chunk of sodium. Have the students describe its appearance. Carefully slice the sodium in half. Show the students the shiny surface and have them observe for about one minute. Have the students explain why the sodium lost its shine.

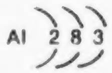
DEVELOPMENT

1. Using the Periodic Table, have students draw a sodium atom. "How can the sodium atom become more stable?" Elicit it must lose its outermost energy level electron.



2. Repeat the above, using magnesium and aluminum.





3. Have students identify metals as elements whose atoms donate electrons in order to complete their outermost energy level.

4. Display a magnesium strip. Have the students describe it. Carefully burn the magnesium strip. CAUTION the students NOT TO LOOK DIRECTLY AT THE BURNING MAGNESIUM!

5. Have the students examine the burned magnesium and describe its properties. Ask, "How has the magnesium changed?" Have the students explain that the magnesium donated its 2 outermost energy level electrons and became more stable. The magnesium reacted with oxygen from the air.

6. Ask: "What is oxygen's electronic configuration?" Have the students conclude that since oxygen had 6 electrons in its outermost energy level, the oxygen accepted magnesium's 2 outermost energy level electrons and both atoms achieved stable electronic configurations.

7. Ask: "What is the name of the compound formed?" Elicit magnesium oxide.

8. Emphasize the fact that the chemical reaction between magnesium and oxygen released energy in the form of LIGHT and HEAT. Tell the students that many chemical reactions release energy.

9. Using the Periodic Table, have students draw an oxygen atom and a chlorine atom. Ask: "How do these atoms become more stable?" Elicit that both atoms gain electrons. Then have students identify nonmetals as elements whose atoms gain electrons in order to complete the outermost energy level.

10. Generalize that atoms with fewer than four electrons in the outer shells behave as metals; they lend electrons. Atoms with more than four electrons in the outer shell behave as nonmetals; they borrow electrons. (See Lesson 14 for the case of atoms with four electrons in their outer shells.)

## SUMMARY

. On the basis of their atomic structures, have students identify the following atoms as either metals or nonmetals:

calcium
sulfur
phosphorus
lithium

## Lesson 13: WHY DO ATOMS COMBINE?

[OPTIONAL]

AIM: "How can we explain the reaction between sodium and chlorine?"

***NOTE TO TEACHER:** True molecules of NaCl are not known to exist except at temperatures over 800°C. To refer, then, to NaCl as a molecule is incorrect. On the ninth grade level, it is best that ionic substances be referred to simply as compounds, and the teacher should remind students that it is only on the chalkboard that one atom of Na reacts with one atom of Cl. In terms of the accepted model of chemical reactivity, many billions of Na atoms react with similarly huge numbers of $Cl_2$ molecules to produce the white crystalline substance we call table salt. The balanced equation for the reaction is $2Na + Cl_2 \rightarrow 2NaCl$.

By using $Na + Cl \rightarrow NaCl$ we are telling students only half of the truth, and concommitantly causing grave problems for the students' future chemistry teachers. The same is true in the case of $2H + O \rightarrow H_2O$ and $Mg + O \rightarrow MgO$ as examples of compound formation.

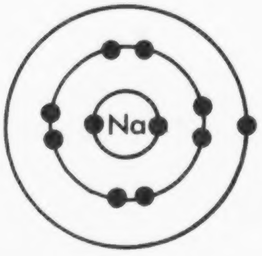
If your students are sophisticated enough to grasp the concept of large numbers of atoms reacting with large numbers of molecules to form ionic or molecular substances, this lesson is appropriate. Otherwise, it is best to omit it entirely or limit the objectives to those of electron transfer and stability as the driving forces behind chemical reactions.

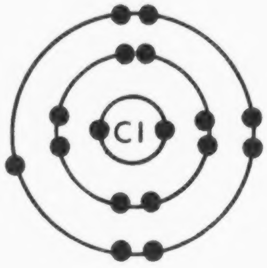
PERFORMANCE OBJECTIVES: The students will be able to:

- describe compound formation as the transfer of electrons among elements.
- relate chemical reactions to breaking and forming of bonds.
- explain why compound formation easily occurs between metals and nonmetals.

MATERIALS: Periodic Table, magnesium ribbon, tongs, Bunsen burner.

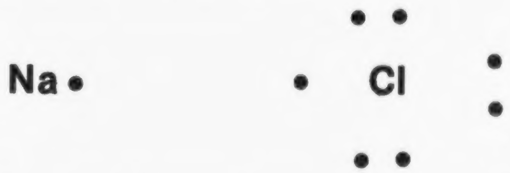
MOTIVATION: Have one student draw an atom of sodium and have another draw an atom of chlorine on the chalkboard. Use dots to represent the electrons. "How can these elements help each other to become more stable?"





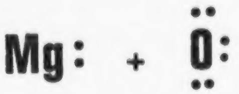
DEVELOPMENT

1. "We are going to use the electron dot method to represent the outer shell electrons only. The only electrons we are going to be concerned with are outer shell electrons."



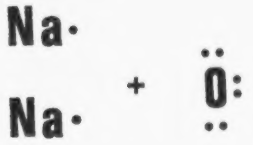
"In transferring the electron from sodium to chlorine a bond is formed. This bond results in the formation of the compound sodium chloride."

2. Burn a piece of magnesium ribbon. Ask: "How can we represent this reaction in terms of the atoms using the electron dot method?"



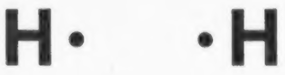
Elicit that a molecule of magnesium oxide contains one atom of magnesium and one atom of oxygen.

3. "What happens when sodium combines with oxygen?"



Elicit that one molecule of sodium oxide contains 2 atoms of sodium and one of oxygen.

4. Write on the board $H_2$, $O_2$, $H_2O$. Ask: "Why are they written like this?" Elicit that certain elements exist as diatomic molecules. Ask the class to draw a molecule of hydrogen using electron dots.



Ask: "How can each of these atoms become stable?" Elicit that hydrogen cannot give up an electron in this case. There is a sharing of electrons in forming the bond.

"$H_2$ is called a molecule of hydrogen. It is called a diatomic molecule."

5. Discuss the two types of bonding, but do not use terms ionic and covalent.

SUMMARY

1. "How do electrons affect bonding?"
2. Using electron dot diagrams, demonstrate how a molecule of each is formed:

Lithium flouride - LiF
Water - $H_2O$
Molecule of oxygen - $O_2$

## Lesson 14: HOW DOES CARBON FORM COMPOUNDS?

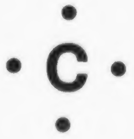
AIM: "How does carbon react with hydrogen?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe how carbon atoms form molecules with other elements.
- relate the electron's properties to the multitude of compounds that can be formed from the carbon atom.
- relate the chemistry of the carbon atom to the chemistry of life.

MATERIALS: Bottles of carbon compounds, atomic model for carbon atom.

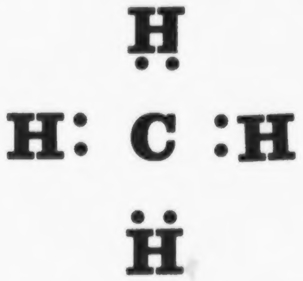
MOTIVATION: Have students draw an electron dot diagram of carbon on the board. "How does carbon form compounds?" Elicit that carbon can gain, lose, or share electrons.



$\cdot\overset{\cdot}{\underset{\cdot}{C}}\cdot$

DEVELOPMENT

1. Tell the class that the atom most commonly joined with carbon is hydrogen.
    a. Ask: "How many hydrogen atoms are necessary to form the simplest carbon compound?"
    b. Have the class use electron dot diagrams to draw a picture of this compound. Have a student place this diagram on board.



$H:\overset{H}{\underset{H}{\overset{..}{\underset{..}{C}}}}:H$

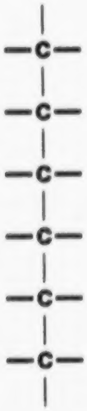
Emphasize that this compound is formed by bonds in which electrons are shared.

    c. Identify the compound methane for the class, and describe it as $CH_4$.
    d. "Since carbon forms bonds by sharing electrons, what other elements would you expect to combine with carbon?" Use carbon dioxide as an example.

2. Ask: "Why can carbon atoms form large molecules?" Elicit that carbon has four bond sites and that a single carbon atom can share its electrons with four other atoms at once.

   Use the board drawings and/or atomic models to show class that carbon atoms generally share electrons with other carbon atoms.

   Draw a carbon chain skeleton on the board.



   a. Ask: "How many carbon atoms can be in a single chain?" "Why can carbon form complex materials?" "Why is the chemistry of the carbon atom essential to life on earth?"

   b. Discuss the relationship between carbon atoms and "life" compounds.

   c. Introduce the branch of chemistry known as organic chemistry. Emphasize that without the complex carbon atom there could be no life.

SUMMARY

1. Display a large number of carbon compounds; include a variety of foods. Ask: "Why is carbon able to form so many kinds of compounds?"

2. "Why is the chemistry of carbon unique?"

FOR FURTHER THOUGHT

1. Have students study drawings of carbon compound polymers in textbook or on teacher-prepared material that has been duplicated.

2. One carbon atom has four outer electrons. Hydrogen atoms do not exist in nature as single atoms, but are found as the diatomic molecule $H_2$. "How many hydrogen molecules can combine with two carbon atoms to form methane?" "How many methane molecules will form?"

# Lesson 15: HOW DO CHEMICAL REACTIONS PRODUCE ENERGY?

AIM: "How does the mass of an unused flashcube compare with the mass of a used flashcube?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe the law of conservation of energy.
- relate the energy in a chemical reaction to the movement of electrons.
- state that energy used in a chemical reaction is either absorbed by the atom or released by it.
- design an experiment to test hypotheses.
- evaluate and explain experimental results.

MATERIALS: Unused flashcube, camera, triple beam or other type of balance, flashlight, wet cell (Zn-Cu, sulfuric acid).

MOTIVATION: Display a flashcube. Ask the class to describe what occurs when the flashcube is used. Lead the students to question how the use of the flashcube affects its mass.

DEVELOPMENT

1. Ask: "How does using the flashcube affect its mass?" Have the students suggest ways of solving the problem. Lead the students to state that there are three hypotheses. The flashcube's mass may increase, decrease, or remain unchanged after use.

2. Test the hypotheses by "massing" the flashcube on a sensitive balance before use. Record on board. Place the flashcube in a camera, have the students observe the flash carefully. Mass the flashcube after use (NO CHANGE).

3. Have the students explain the results. Elicit magnesium or aluminum in the flashcube combined with oxygen in the flashcube. Instead of two separate elements, a compound is now present - $MgO$.

4. Guide the students to conclude that matter was not created nor destroyed, but simply changed its form.

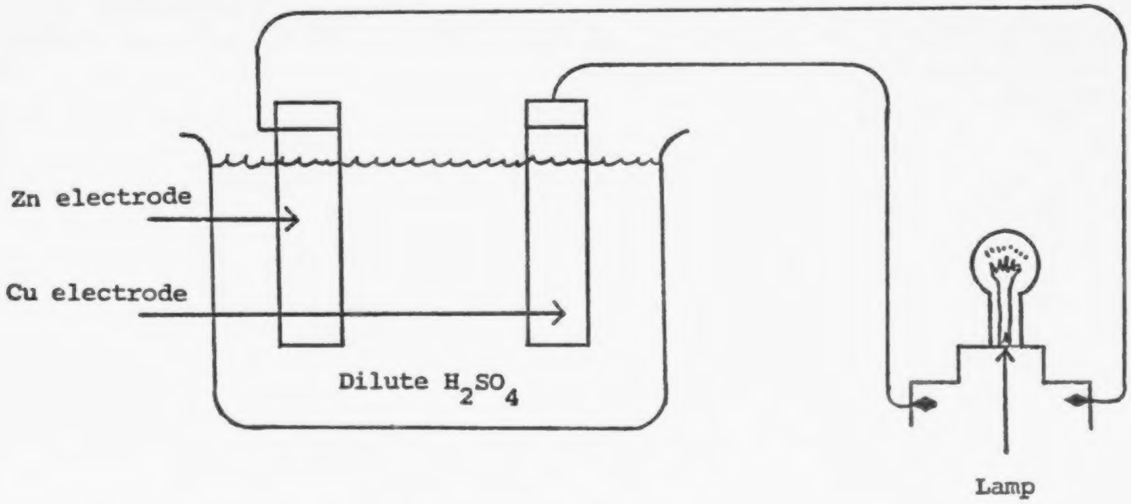
5. Ask: "What evidence indicates that using the flashcube released energy?" Elicit light and heat were released when the flashcube was used. Tell the students that chemical reactions that release energy are called EXOTHERMIC REACTIONS.

6. Refer to Lesson 12 in which a strip of magnesium ribbon was burned. Have the students explain that burning a magnesium strip is an exothermic reaction.

7. Place some sugar into a 250 ml. beaker and carefully add about 15 ml. of concentrated sulfuric acid to the sugar. Allow the mixture to stand on the laboratory table for a few minutes. The sugar will turn "syrupy," and carbon will be released, along with water and heat. Have the students describe what they observe, and identify the reaction as EXOTHERMIC.

8. Shine a flashlight. Tell the class that this is another example of a chemical reaction. Ask: "What is chemical energy?" The students should explain that it is energy stored in the particles that make up substances; it is released during chemical changes.

9. Set up a wet cell:



   a. "What evidence do you see that a chemical reaction is taking place?"

   b. "What evidence is there that this chemical reaction is producing energy?"

   c. "How can the wet cell be used to illustrate the transformation of energy?"

   d. "What is the source of this energy?" (Discuss the existence of cathode and anode and relate this to flow of electrons in the solution and through the wires. Students do not need to learn definitions of anode and cathode.)

   e. "How can the wet cell be used to demonstrate the law of conservation of energy?"

10. Have the class list all sources of energy that are used in their homes. Ask: "How do chemical reactions make these sources available to us?" Elicit that burning of fuels produces the energy used in their homes.

SUMMARY

1. Refer to flashlight demonstration used in Motivation. Develop a drawing of the inside of a flashlight battery and ask: "How does this demonstrate the conversion of one form of energy into another?"

2. "How do chemical reactions produce energy?"

## FOR FURTHER THOUGHT

1. "Why can most forms of energy be traced to chemical reactions?"

2. "We say that atoms give off energy. Where does an atom get this energy?" ($E = mc^2$ refers to the loss of mass.)

3. "Why can't we detect the change in mass with a triple beam balance when an atom gives off energy?"

***NOTE TO TEACHER:** The equation can also be used to calculate the energy when a positron collides with an electron. All of these masses change to energy.

## Lesson 16: WHAT IS RADIOACTIVITY?

AIM: "How does uranium release energy without undergoing a chemical reaction?"

PERFORMANCE OBJECTIVES: The students will be able to:

- compare emissions from radioactive elements.
- explain why some atoms are radioactive.
- relate half-life to the rate of radioactive decay.
- describe the differences between radioactive and nonradioactive elements.
- define radioactive isotopes.

MATERIALS: Geiger counter, radioactive sources, samples of nonradioactive elements, model of an atom.

MOTIVATION: Show the class a radioactive source, such as uranium. Use a Geiger counter to detect the radiation. Ask, "What does each 'click' indicate?" Guide the students to conclude that the radioactive source is releasing energy spontaneously. The Geiger counter detects the energy.

DEVELOPMENT

1. Ask: "How do the chemical energy sources previously studied differ from the radioactive energy sources?" Elicit the previous energy sources involved outermost energy level electrons, while readioactivity involves the atom's nucleus.

2. Ask: "How can you measure the energy in the nucleus of the atom?"

   a. "Since protons have like charges they repel each other. It takes a powerful force to hold them together. This attraction is called binding energy."

   b. "Some nuclei have a small amount of binding energy. The protons and neutrons of these atoms are not tightly bound. Such nuclei are said to be unstable. An atom with an unstable nucleus may change to become more stable. An atom whose nucleus changes to become more stable is said to be radioactive. How can we explain radioactivity?"

   "Radioactivity is the result of a change in the nucleus of an atom, the result of a nuclear reaction. The nuclei of certain elements are unstable. If a substance is radioactive, its nuclei break apart spontaneously. Particles are released, often along with large amounts of energy. A new atom, slightly different in mass from the original, will remain. Such changes continue in a series of steps until a nonradioactive element has been formed."

***NOTE TO TEACHER:** If all the material in this lesson is taught, several forty-minute periods will be necessary.

c. Ask: "What is an isotope?" Using a textbook, or other source, have the students read a paragraph describing atoms and their isotopes. Elicit that since most elements contain atoms with differing numbers of neutrons in their nuclei (isotopes), any sample of a "pure" element would contain mixtures of atoms. Students should know the three isotopic forms of hydrogen: protium, deuterium and tritium.

3. a. Ask: "What effects might extra (or fewer) neutrons have on the stability of an atom's nucleus?" Elicit that some atoms are radioactive, and actually change into other elements by releasing small particles from their nuclei(us).

b. Demonstrate a Geiger counter with a radioactive source. Ask: "Why does the Geiger counter click?" Elicit that the nuclei of the atoms are giving off particles of radiation that activate the Geiger counter.

4. Ask: "What are some ways that an unstable nucleus can become more stable?"

a. "Alpha decay takes place when a nucleus shoots out a particle made up of two protons and two neutrons. An alpha particle is a helium nucleus." Example:

$$^{226}_{88}\mathrm{Ra} \longrightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He}$$

b. "Beta decay causes an electron to be shot out of the nucleus at high speed." Ask: "How did the electron get into the nucleus?"

Elicit that a beta particle is formed when a neutron inside the nucleus loses an electron and changes into a proton. This electron leaves the nucleus as a beta particle. Example:

$$^{12}_{6}\mathrm{C} \longrightarrow {}^{12}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}$$

c. "Gamma decay is unlike alpha and beta decay in that emissions of gamma rays do not cause an atom to change into another kind of atom. Gamma rays are not atomic particles. Gamma rays can penetrate most materials readily." Ask: "How can we detect gamma rays?" Elicit that we use a Geiger counter. Use a Geiger counter on a group of nonradioactive elements. Ask: "Why does the Geiger counter detect no radiation here?"

5. Ask: "How long does something remain radioactive?" Develop the idea that radioactivity continues until the atom has changed into a stable form. Example:

   $^{238}U \longrightarrow {}^{208}Pb$ + alpha particles, beta particles and gamma rays

   Introduce the term "radioactive decay." Explain that radioactive decay is the breaking up of the nucleus of an atom. During radioactive decay all radioactive materials give off gamma rays. In addition some give off alpha particles, and some give off beta particles.

   $$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He + \text{gamma rays}$$

6. Develop the concept of half-life. Explain that half-life is the time it takes for half of the nuclei of a radioactive isotope to decay. For example, barium-139, 82.9 minutes; carbon-14, 5770 years; uranium-238, 4.5 billion years.

## SUMMARY

1. "Why are some elements radioactive?"
2. "Why do radioactive atoms change into other forms?"
3. "How is half-life used to measure radioactive change?"

## FOR FURTHER THOUGHT

1. "A radioactive element has a half-life of three years. From an original sample of 20 grams, how much will remain after 12 years? What becomes of the rest of the material?"
2. "How do scientists conclude that the half-life of $^{14}C$ is 5770 years? After all, we only discovered radioactivity fairly recently, and no one has been known to live for 5770 years!"

# ADDITIONAL IN-CLASSROOM ACTIVITY

## SUGGESTED ACTIVITIES

1. Start a current events board dealing with news about nuclear energy, nuclear wastes, and the advantages and dangers caused by the use of nuclear energy. Have class summarize and discuss each article.

2. As an outgrowth of the current events discussions, set up a debate team to discuss the pros and cons of the use of nuclear energy. A good source is "The Promise and Peril of Nuclear Energy," in *National Geographic*, Vol. 155, No. 4, April 1979.

3. "How are the geologist and archeologist able to tell the ages of the 'finds' that they make?" Elicit bone samples, rocks, tombs, etc.

## ESSENTIAL VOCABULARY

1. emission
2. radioactive
3. half-life
4. decay
5. radiation
6. isotope
7. constant
8. fusion
9. fission
10. chain reaction

## Lesson 17: HOW DO WE MEASURE RADIOACTIVE DECAY?

AIM: "What is radioactive iodine's half-life?"

PERFORMANCE OBJECTIVES: The students will be able to:

. relate half-life to the amount of radioactive decay.
. prepare and interpret results graphically.
. determine the half-life of iodine-131 using a graph.

MATERIALS: See Laboratory Worksheet 2.4.

MOTIVATION: Explain that in medicine, radioactive isotopes are used for testing and treatment. Tracer elements can be used to check the functioning of bodily systems. Ask: "How is this possible?"

DEVELOPMENT

1. Distribute Laboratory Worksheet 2.4. Each student is to be given his or her own piece of graph paper.

2. The teacher should set up a sample graph on the board and plot the first two points. (See Worksheet 2.4).

3. Emphasize that the line drawn to connect points must be smooth and done freehand.

4. Introduce the class to the use of half-lives. Sample elements:

   $^{14}C$ - 5730 years

   $^{60}Co$ - 5 years

   $^{59}Fe$ - 45 days

   $^{238}U$ - 4.5 million years

   Ask: "How can we use each of these to help us?"

SUMMARY

. See Laboratory Worksheet 2.4.

# LABORATORY WORKSHEET 2.4

NAME ________________________________ CLASS __________ DATE ____________

PROBLEM: How do we measure radioactive decay?

MATERIALS: Graph paper, ruler, pencil.

INTRODUCTION: Half-life is the amount of time required for one half of a quantity of radioactive material to decay. Each radioactive element has a half-life that is both specific and constant. Today you will use a graphing technique to determine the half-life of one radioactive element.

PROCEDURE

1. Prepare your graph according to the directions given by your teacher.
2. The columns of figures below represent results of experiments done to determine the half-life of radioactive iodine.

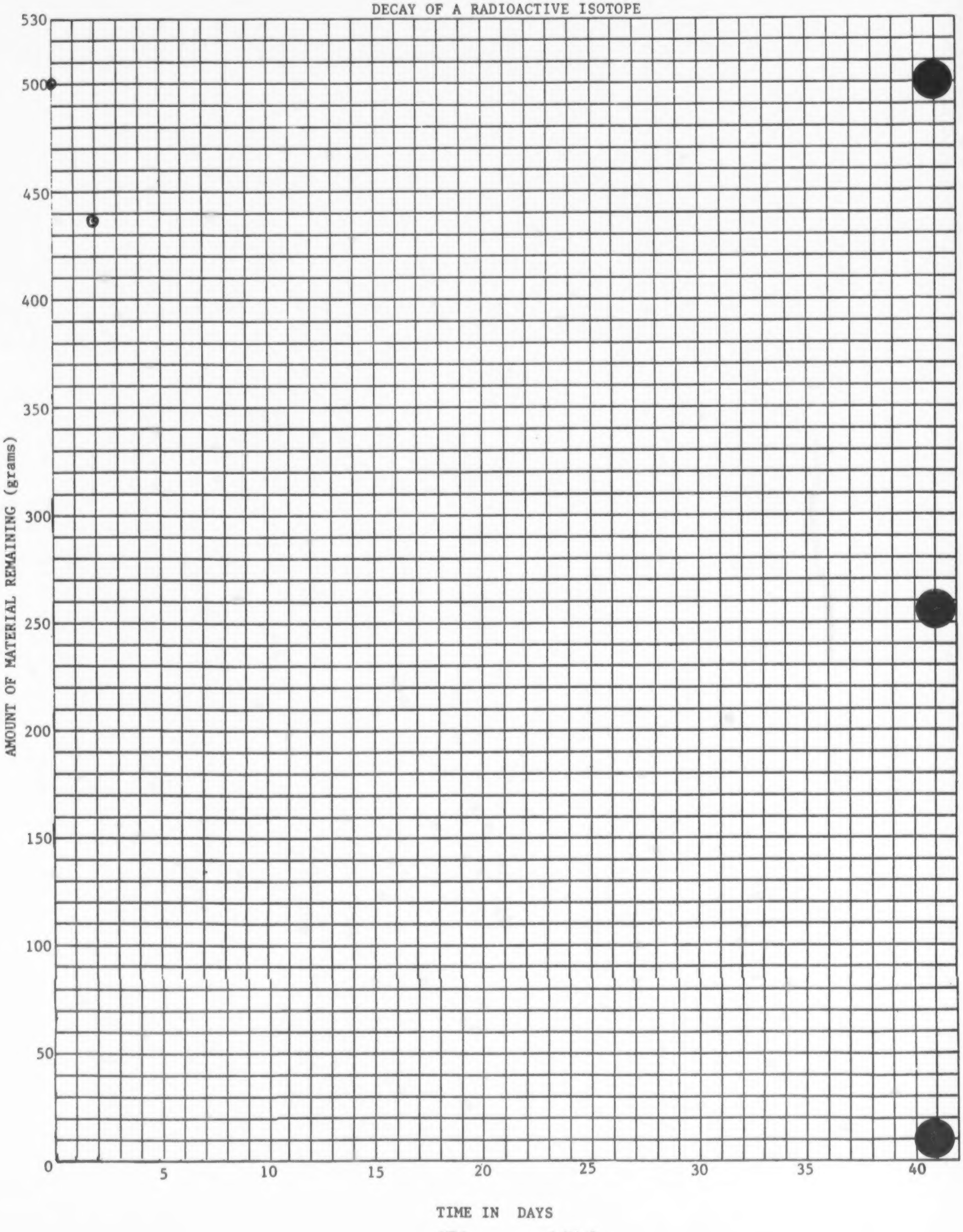
| Time in Days | Grams of $^{131}I$ |
|---|---|
| 0 | 500 |
| 2 | 437 |
| 4 | 375 |
| 8 | 250 |
| 12 | 187 |
| 16 | 125 |
| 20 | 93.5 |
| 24 | 62.5 |
| 28 | 47 |
| 32 | 31.3 |
| 36 | 23.5 |
| 40 | 15.7 |

Plot these data on your graph.

3. Draw a smooth line connecting the data points.

**Name** ______________________ **Class** ______________

DECAY OF A RADIOACTIVE ISOTOPE



# LABORATORY WORKSHEET 2.4 (continued)

NAME: ______________________________

SUMMARY/HOMEWORK

1. How can this graph be used to determine the half-life of $^{131}$I?

2. According to your graph, what is the half-life of $^{131}$I? ________________.

3. Predict the amount of $^{131}$I remaining after ten days. How did you arrive at your answer?

# Lesson 18: HOW CAN WE USE NUCLEAR ENERGY?

AIM: "How do fission and fusion differ?"

PERFORMANCE OBJECTIVES: The students will be able to:

. contrast fusion and fission reactions.
. identify a variety of uses for nuclear energy.

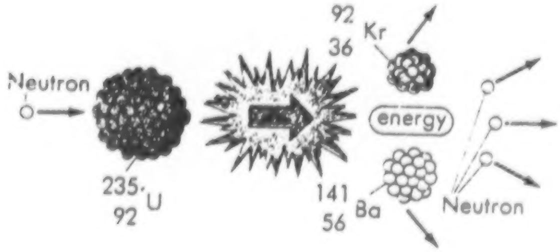
MATERIALS: Overhead projector.

MOTIVATION: "Alchemists tried to change one element into another. Little did they know that this change occurred in the process of radioactivity. How does the knowledge of radioactivity aid us today?"

DEVELOPMENT

1. Demonstrate the idea of a chain reaction by using matches or dominoes. Have students explain the steps in this analogy. Ask: "Why is this called a chain reaction?" Explain a chain reaction is a series of continuous rapid nuclear fissions.

2. Place a diagram of a chain reaction on the board or prepare a transparency and use an overhead projector:



FISSION

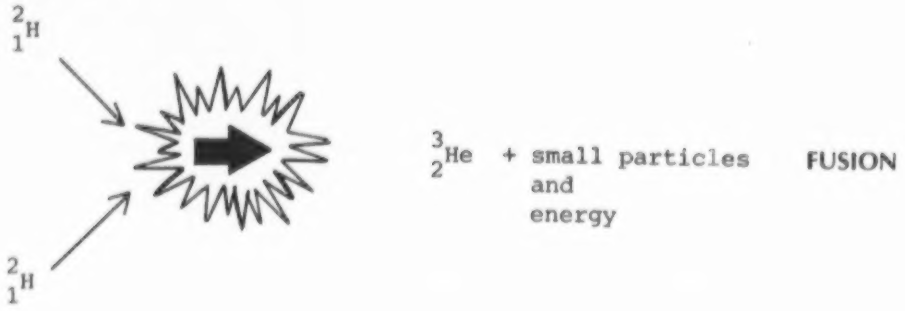
3. Ask: "What happens during a chain reaction?" "How can this reaction be used to show the relationship between matter and energy?" Elicit from the class that this is an example of a fission reaction, the splitting of an atom, with the release of energy and neutrons.

4. Explain that three things happen as a result of nuclear fission.

   a. Some of the matter in the nucleus is changed to energy.
   b. Two new elements are formed.
   c. More neutrons are released that can cause more fissions (chain reactions).

5. Ask: "What is an uncontrolled chain reaction?" Identify a nuclear bomb as a runaway chain reaction. Ask: "Why is it important that a chain reaction be controlled?"

6. Place the following diagram on the board:



Define fusion as the formation of a larger atomic nucleus from two smaller ones at very high temperatures. The process always produces a greater amount of energy than that needed to bring it about.

7. Ask: "How might nuclear energy be used to produce electricity?" Explain that most nuclear power plants produce electrical energy by heating water under pressure to a high temperature. The fast-moving particles and radiation produced during fission heat metal pipes. Water passing through the pipes boil into steam. The steam pushes fanlike blades to make electricity.

8. Ask: "What is a fusion reaction?" Elicit that two or more light nuclei combine to produce a heavier nucleus. Ask: "How can we use the concept of fusion to explain why stars shine?"

9. Ask: "How are fission reactions different from fusion reactions?"

10. Ask: "How can we use nuclear energy?" Explain one use of nuclear energy is the heat from nuclear fission is used to boil sea water and purify it by separating the water from the dissolved minerals. Elicit other uses, such as generating electricity, from the class.

SUMMARY

1. "Why are fission reactions easier to control than fusion reactions?"

2. "Why does splitting a large nucleus result in the release of energy?"

3. "How can we obtain electrical energy from nuclear energy?"

4. "Where in the New York City area is nuclear energy used to generate electricity?"

# Theme II — Questions for Review

NOTE: The following questions do not constitute a test. Specific questions may be selected to help the teacher to construct an examination.

Unit I. It's All Elementary

NAME ______________________________ CLASS ____________ DATE _______________

1. After steel wool is heated in air its mass:
   - a. remains the same
   - b. decreases slightly
   - c. increases slightly
   - d. increases naturally

2. An element with luster and malleability is generally considered to be:
   - a. a nonmetal
   - b. a metal
   - c. a gas
   - d. a nonconductor

3. The modern Periodic Table shows:
   - a. an alphabetical listing of the elements
   - b. an arrangement of the elements in order of increasing atomic number
   - c. an arrangement of metals and their compounds
   - d. an arrangement of elements in order of decreasing atomic mass

4. When steel wool is burned in air:
   - a. it evaporates
   - b. it combines with oxygen
   - c. carbon dioxide is given off
   - d. water vapor is given off

5. The smallest particle of an element that retains the properties of the element is:
   - a. a photon
   - b. an atom
   - c. an electron
   - d. a proton

6. The attraction of a rubbed comb for paper gives evidence that:
   - a. matter is electrical in nature
   - b. matter is magnetic
   - c. matter has mass
   - d. matter is electrically neutral

7. The central portion of the atom is called the:
   - a. nucleus
   - b. shell
   - c. electron
   - d. ring

NAME ________________________________

8. The atomic number of an element indicates:
    - a. the number of protons only
    - b. the number of neutrons only
    - c. the number of protons and neutrons
    - d. the number of electron shells

9. The atomic mass of an element is equal to the mass of the:
    - a. protons
    - b. protons and neutrons
    - c. neutrons
    - d. electrons

10. Of the following, the particle with the least mass is the:
    - a. electron
    - b. atom
    - c. proton
    - d. neutron

11. An atom is neutral when it has the same number of electrons as:
    - a. energy levels
    - b. neutrons
    - c. protons
    - d. isotopes

12. To achieve stability when it combines with chlorine, a sodium atom will:
    - a. accept 1 electron
    - b. accept 7 electrons
    - c. donate 1 electron
    - d. donate 7 electrons

13. Most of the elements in the Periodic Table have the properties of:
    - a. gases
    - b. compounds
    - c. metals
    - d. nonmetals

14. A family of elements in the Periodic Table:
    - a. is always made up of metals
    - b. contains elements having similar properties
    - c. contains elements which combine with one another
    - d. is always made up of nonmetals.

15. An atom with 6 electrons in its outermost shell could be:
    - a. a metal
    - b. a nonmetal
    - c. a conductor
    - d. a suspension

NAME ______________________________

16. Neon does not combine with other elements because:
    - a. neon is a compound
    - b. a neon atom has the same number of protons and electrons
    - c. a neon atom has a complete outermost shell
    - d. a neon atom is diatomic

Questions 17-20 refer to the following:

A certain element has an atomic number of 11 and an atomic mass of 23. In order to answer the following, refer to the Periodic Table.

17. How many neutrons are there in the nucleus of an atom of this element?
    - a. 11
    - b. 12
    - c. 22
    - d. 24

18. How many protons are there in the nucleus of this atom?
    - a. 11
    - b. 12
    - c. 22
    - d. 24

19. During a chemical change an atom of this element will tend to:
    - a. lose one electron
    - b. gain one electron
    - c. gain two electrons
    - d. lose two electrons

20. This element will have the chemical properties of a:
    - a. metal
    - b. non-metal
    - c. gas
    - d. compound

True - False

21. _______ An element that does not react with other elements is said to be bonded.

22. _______ Atoms of different elements unite during chemical changes to produce new elements.

NAME ________________________________

True - False

23. _______ When the outermost shell of an atom becomes complete, the element is said to be unstable.

24. _______ Vertical rows on the Periodic Table are called periods.

25. _______ Metals are located toward the right on the Periodic Table.

Explain each of the following:

26. Inert gases do not readily combine with other elements.

27. The outermost shell is most important in chemical changes.

28. Metals are lenders of electrons.

29. Why do all members of a family, or group, have similar properties?

30. How are chemical bonds important?

Multiple choice:

31. Elements that have the same atomic number but different atomic masses are called:
    a. ions
    b. nonmetals
    c. isotopes
    d. metals

32. When a radioactive element emits radiation and changes to a different element, it is said to undergo:
    a. a physical change
    b. radioactive decay
    c. a chemical change
    d. atomic fusion

33. An alpha particle is a:
    a. helium nucleus
    b. hydrogen nucleus
    c. helium atom
    d. hydrogen atom

34. High-speed electrons emitted from the nuclei of atoms are called:
    a. beta particles
    b. gamma rays
    c. alpha particles
    d. ions

NAME ________________________________

35. Gamma rays have:
   a. a positive charge
   b. a negative charge
   c. both a positive and negative charge
   d. no charge

36. When an atom emits radiation, the mass of the atom:
   a. becomes half as great
   b. doubles
   c. triples
   d. decreases slightly

37. The final stable element formed from the radioactive decay of uranium is:
   a. thorium
   b. lead
   c. plutonium
   d. silver

38. If an original sample of carbon-14 has a mass of ten grams and the half-life of carbon-14 is 5700 years, at the end of 5700 years the amount of carbon-14 remaining would be:
   a. 2.5 grams
   b. 5 grams
   c. 10 grams
   d. 8 grams

39. Radioisotopes that are used to track a chemical pathway are called:
   a. ions
   b. tracers
   c. atomic cocktails
   d. radiators

40. The half-life of a radioactive isotope is six months. Of 400 grams, how many will remain after 1 year?
   a. 25
   b. 50
   c. 100
   d. 200

41. A radioactive isotope of hydrogen is:
   a. common hydrogen
   b. deuterium
   c. a chemical change
   d. atomic fusion

NAME ________________________________

Questions 42 - 49 refer to the following, as well as to class activities:

Tyrone massed a piece of steel wool (iron). Its mass was 4.1 g. He picked up the steel wool with a pair of tongs, ignited the steel wool, and gently exhaled onto the steel wool until it was completely burned. Tyrone massed the steel wool after it was burned.

42. The mass of the steel wool after burning should be:
    - a. less than before burning
    - b. greater after burning
    - c. the same as before burning
    - d. equal to the mass of the oxygen in the room

43. A possible variable in Tyrone's experiment is:
    - a. steel wool is not the proper substance to use
    - b. some steel wool particles might fall to the ground and not be massed
    - c. Scott compared the steel wool's mass before and after burning
    - d. steel wool is used for scrubbing pots

44. Some moisture from Tyrone's breath might have gotten onto the steel wool. This is:
    - a. a control
    - b. an unimportant factor
    - c. a variable
    - d. the major purpose of the experiment

45. Tyrone performed an experiment because he:
    - a. exhaled and burned the steel wool
    - b. compared the steel wool's mass before and after burning
    - c. wished to test a hypotheses
    - d. reached a conclusion

46. Tyrone wanted to discover how burning steel wool affected the steel wool's mass. This is Tyrone's:
    - a. problem
    - b. hypotheses
    - c. observation
    - d. conclusion

47. An acceptable hypothesis is that after burning, the steel wool's mass will be:
    - a. increased
    - b. decreased
    - c. unchanged
    - d. all or any of the above
    - e. none of the above

NAME ____________________________________

48. The substance formed after burning the steel wool in air is:
  a. an element
  b. a compound
  c. a mixture
  d. an unknown, newly created substance

49. A good idea would be for Tyrone to:
  a. repeat burning steel wool, using fresh pieces of steel wool
  b. keep careful records of his procedures
  c. have another student do the experiment independently
  d. all of the above

50. Scientists have never seen an atom, yet act and think as if they had. The atom is:
  a. false belief
  b. a hypothesis
  c. a model
  d. a small compound that cannot be detected

51. Frank heated a test tube containing small beads floating on mercury. The beads began to jump because:
  a. the beads acquired energy from the mercury, which acquired energy from the flame
  b. Frank shook the test tube
  c. atoms are in constant motion
  d. the beads transferred energy to the mercury

52. Dust particles suspended in air move randomly in all directions. Scientists believe that the dust particles' motion is caused by:
  a. the dust particles' own energy
  b. air molecules bumping the dust particles
  c. light shining onto the dust particles
  d. the fact that the dust particles are always in motion, even in a vacuum

53. We can smell an onion's aroma because:
  a. the onion is matter
  b. the onion is composed of molecules which can travel through the air and reach our noses
  c. we diced or cut the onion
  d. the Kinetic Molecular Theory accounts for molecular motion

NAME ______________________________________

54. Atoms are closest in a:
  a. solid
  b. liquid
  c. gas
  d. vapor

55. Shawna had a balloon in her room. She took her balloon into the cold (below $0^{\circ}$ C) air and the balloon collapsed. This occurred because:
  a. increased pressure forced air out of the balloon
  b. molecules collapsed into themselves
  c. the air molecules in the balloon lost energy due to the cold outside air
  d. air molecules escaped from the balloon

56. Hydrogen is an element that burns, and oxygen is an element that supports combustion; yet water often puts out fires. This is because:
  a. oxygen doesn't burn
  b. elements acquire new properties when they form compounds
  c. water is a mixture of elements
  d. molecules and atoms are similar

57. A magnet could be used to separate:
  a. a mixture of iron and sulfur
  b. a compound of iron sulfide
  c. a compound of iron and oxygen
  d. lead sulfide

58. A rubber rod was rubbed with fur and brought near a negatively charged pith ball. The ball was repelled by the rubber rod. We can conclude that the rubber rod and ball:
  a. had too little charge
  b. were oppositely charged
  c. were composed of atoms
  d. had the same charge

59. When two pith balls are both touched by a rubber rod which has been rubbed against fur, the pith balls:
  a. repel each other
  b. attract each other
  c. are unaffected by the rubber rod that had not been rubbed against fur
  d. both acquire positive charges

NAME ________________________________________

60. Atoms possess the same number of protons as electrons. The net electrical charge on an atom is:
    a. zero
    b. positive
    c. negative
    d. negative if there are more electrons

61. Rachel put some magnesium into a beaker of water, and some sodium into a second, identical beaker of water. Small bubbles formed on the magnesium, but the sodium moved and spun in the water until it disappeared. This indicates that:
    a. magnesium is more active than sodium
    b. sodium is inert
    c. sodium is more active than magnesium
    d. we can draw no conclusions

62. Sodium and potassium are in Group IA on the Periodic Table. We can conclude that:
    a. sodium is more active than potassium
    b. sodium and potassium each have one energy level
    c. sodium and potassium are equally active
    d. sodium and potassium have similar properties

63. Dr. Brown cut a piece of sodium. She showed the shining surface to the class, but within a minute, the surface became dull. This occurred because:
    a. sodium reacted with nitrogen
    b. sodium reacted with oxygen
    c. the air in the room was too cool
    d. her knife was not sharp

64. Magnesium is in Group IIA on the Periodic Table. It has 2 electrons in its outermost energy level. Calcium is in Group IIA on the Periodic Table. The number of electrons in calcium's outermost energy level is:
    a. 1
    b. 2
    c. 8
    d. 18
    e. not enough data to draw a conclusion

65. Element X does not react chemically under any conditions. We can conclude that element X:
    a. was not fully or adequately tested
    b. has 2 electrons in its outermost energy level
    c. is probably helium
    d. has a complete outermost energy level

NAME ______________________________

66. Karen massed an unused flashcube. She used the flashcube, and massed it again. The flashcube's mass:
    a. increased
    b. decreased
    c. remained the same
    d. changed because it reacted with oxygen

67. A Geiger Counter was brought close to an unknown rock sample. The number of counts or clicks per minute increased. We can conclude that the rock sample:
    a. was radioactive
    b. was probably uranium
    c. came from a nuclear reactor
    d. was very old

68. Element X has an atomic number of 88 and an atomic mass of 226. It emits an alpha particle ($^4_2He$). The new element formed has an atomic number of:
    a. 86
    b. 90
    c. 92
    d. 84

69. Element X has a half-life of 14 days. You have 16 g. of element X. The number of grams of element X you will have after 42 days is:
    a. 8
    b. 4
    c. 2
    d. 0

70. When two hydrogen nuclei FUSE to form helium, the helium's mass is slightly less than the mass of the two hydrogen atoms. This is because:
    a. matter was destroyed
    b. energy was destroyed
    c. matter was converted to energy
    d. energy was converted to matter

# UNIT 2. HEAT ON EARTH

# Introduction

The following topics are covered in the curriculum bulletin Science Grade 7, Unit 2 - Physics:

- How heat affects the size of matter
- How temperature is measured
- What is heat
- How heat travels
- How heat is measured

Some of this material is also covered again in the grade 9 curriculum. You may wish to omit material if your students have previously covered it or you may wish to teach a review lesson.

A pretest has been included so that you can determine the students' level of knowledge and to help you to proceed.

> ***NOTE TO TEACHER:** Lesson 7 calls upon the teacher to ask students to bring in empty cans, such as soup cans or vegetable cans, if no calorimeter is available. This will have to be done several days prior to teaching the lesson.

# Pretest

## Unit 2 - Heat on Earth

NAME________________________________ CLASS__________ DATE ______________________

1. Heat always moves from regions of high temperature to regions:
   - a. of higher temperature
   - b. of lower temperature
   - c. with the same temperature
   - d. none of the above

2. The unit used to measure heat is the:
   - a. Newton
   - b. watt
   - c. meter
   - d. calorie

3. A steel building is taller in summer than in winter because:
   - a. The building has more particles in summer.
   - b. The spaces between its particles become smaller.
   - c. The spaces between its particles become greater.
   - d. Its particles move more slowly in summer.

4. Energy from the sun reaches the earth through:
   - a. radiation
   - b. convection
   - c. conduction
   - d. circulation

5. As an object's temperature decreases, its particles:
   - a. stop moving
   - b. gain kinetic energy
   - c. slow down
   - d. hit other particles more vigorously

6. A thermostat uses the property of:
   - a. radiation
   - b. contraction
   - c. color
   - d. potential energy

7. When a brass ball is heated in a flame it:
   - a. remains unchanged
   - b. expands
   - c. contracts
   - d. splits

NAME________________________________________

8. Thermostats contain a:
    a. compound bar
    b. bar of silver
    c. bar of iron
    d. bar of steel

9. All gases, when heated:
    a. do not expand
    b. expand at the same rate
    c. expand at different rates
    d. contract, but do not expand

10. The rising column of smoke from a smokestack is mainly due to:
    a. conduction
    b. convection
    c. radiation
    d. induction

11. Heat is transferred through a solid by the process of:
    a. conduction
    b. convection
    c. radiation
    d. induction

12. When a body is heated, the molecules:
    a. contract
    b. move close together
    c. move more slowly
    d. move faster

13. Thermometers indicate:
    a. heat
    b. temperature
    c. calories
    d. distance

14. The number of calories required to raise the temperature of one gram of water one degree Celsius is:
    a. 1/10
    b. 1
    c. 10
    d. 100

15. Temperature tells how hot an object is. Heat tells:
    a. how cold an object is
    b. how much energy an object has
    c. how much matter is in an object
    d. how much an object's temperature has changed

## Lesson 1: HOW IS HEAT TRANSFERRED BY CONDUCTION?

[OPTIONAL]

AIM: "Why did the wax melt?"

PERFORMANCE OBJECTIVES: The students will be able to:

. relate heat to the kinetic molecular theory.
. describe heat transfer through solids.
. identify conduction of heat as a function of the kinetic energy of molecules.

MATERIALS: Conductivity wheel, wax (melt wax before class), Stoekle's tube, long metal rod, balloon, flask.

MOTIVATION: Demonstrate conductivity wheel. Ask: "Why did the wax melt?"

DEVELOPMENT

1. Demonstrate that addition of heat increases molecular motion. Prepare Stoekle's tube or crystals of sodium chloride in a test tube. Heat apparatus. Ask: "Why do the glass beads (salt crystals) jump?"

2. Have a student hold a long metal rod in a flame until he or she feels the increased temperature. Ask: "Why did the rod get hot?" "How was the heating of the rod similar to the jumping of the beads (salt crystals)?"

3. Kinetic molecular theory: Matter is made up of atoms and molecules that are in constant motion. This motion results in kinetic energy. The higher the temperature, the greater the speed of the molecules and the greater the kinetic energy of the molecules. Elicit:

   a. All matter is made up of molecules.
   b. These molecules are in constant motion.
   c. Heat is a form of energy that can be absorbed by molecules.
   d. Molecules move faster at higher temperatures.

4. Refer to conductivity wheel.

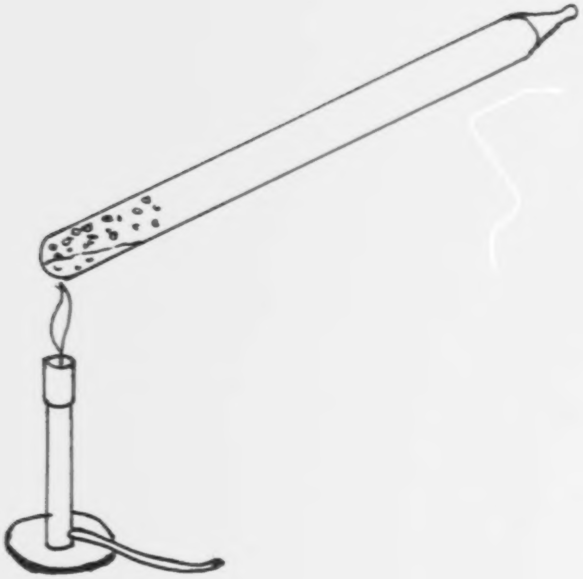
   a. "How does the heat at the center reach the wax at the tips?"
   b. "Why does the wax at the end of each rod melt at different times?"

5. Develop a definition of conduction as a method of heat transfer (heat energy that is transferred from molecule to molecule by direct contact).

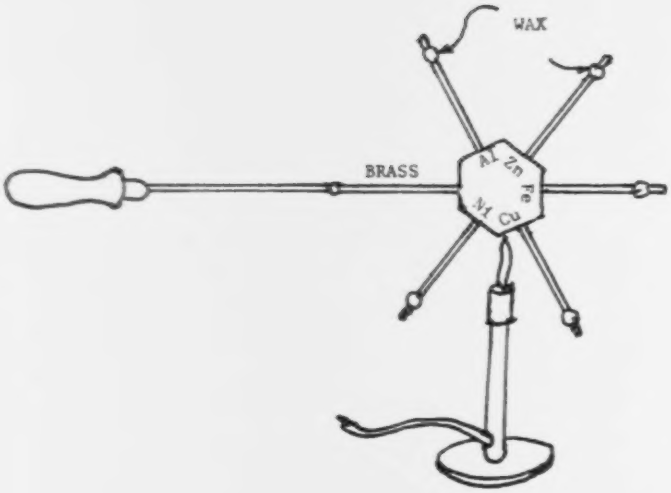
## SUMMARY

- Stretch the opening of a balloon over the top of a flask. Place the flask on a tripod and heat it gently.

    1. "Why does the balloon expand?" Relate to kinetic molecular theory.
    2. "How could the balloon be made to collapse without removing any of the air?"



STOECKLE'S TUBE


WAX
BRASS
Al
Zn
Fe
Ni
Cu

CONDUCTIVITY WHEEL
(OR CONDUCTIVITY OF METALS APPARATUS)

## Lesson 2: HOW IS HEAT TRANSFERRED BY CONVECTION?

**AIM:** "Why DOESN'T the smoke rise?"

**PERFORMANCE OBJECTIVES:** The students will be able to:

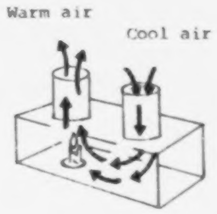
- define convection as the transfer of heat energy by the movement of liquids and gases.
- design an experiment to explain convection.

**MATERIALS:** Candle, convection box.

**MOTIVATION:** Show class a picture of a factory with smoke coming out of its chimneys. "Why does the smoke rise inside chimney stacks?"

### DEVELOPMENT

1. Set up a convection box. Light the candle, and then place cigarette or "touch" paper over the chimney OPPOSITE the candle. Have the students describe what they observe. (The smoke should be seen moving DOWN the chimney, across the box, and out through the other chimney. This occurs because as the air over the candle is heated, it becomes less dense and rises, leaving a partial vacuum. Cooler, more dense air from the first chimney moves in to fill the partial vacuum.)



2. Ask: "Why does smoke rise through only one chimney?" Develop a hypothesis and a method of solution. The class should conclude that warm air rises through the chimney and that cool air enters the second chimney to replace the warm air that has been pushed out. From this experiment, a definition of convection should develop. Elicit: CONVECTION is the transfer of heat by movement of gases and/or liquids.
3. Ask: "How is a small room with a radiator at one end similar to a convection box?"

### SUMMARY

Light a candle.

1. "How is the principle of convection illustrated by this candle?" Refer to Motivation.
2. "Why do people use ceiling fans to reduce energy consumption in the winter?"

## FOR FURTHER THOUGHT

1. "Why does a fireplace often lessen the heated air in a room when the fire is not burning?"

2. "How can glass doors prevent this?"

## Lesson 3: HOW IS HEAT TRANSFERRED BY RADIATION?

AIM: "How does heat from a light bulb near the ceiling reach the table below?"

PERFORMANCE OBJECTIVES: The student will be able to:

- identify a problem for a given situation.
- explain that radiation is heat transfer by means of waves or rays.
- reason inductively and deductively.
- apply scientific facts and principles to specific situations.
- recognize that science consists of tentative models that have been created from available evidence.

MATERIALS: Lamp.

MOTIVATION: Tell the students that you have a hot light above your desk at home. Ask: "How do you explain the fact that the desk top gets warm when the light is on?"

DEVELOPMENT

1. Set up a lamp above the laboratory table. A desk lamp will suffice. Turn the lamp on and have two student volunteers place their hands below the lamp. Ask the students to describe what they feel. The students should indicate that their hands feel warmer.

    a. Ask: "Why do their hands feel warmer?" Elicit the fact that neither conduction nor convection will explain the heat transfer from the lamp to the students' hands.

    b. Explain that air is a poor heat conductor, so that the heat wasn't transferred by conduction. And since warm air rises, the heat wasn't transferred by convection. The heat was transferred from the lamp to the students' hands by RADIATION.

2. Ask: "How does heat from the sun reach the earth?"

    a. The students should eliminate conduction and convection, since there is virtually no matter in the vast distance between the sun and the earth. The sun's heat reaches the earth by radiation.

    b. Tell the students radiation is heat transfer by waves, but a wave of water needs a medium through which to travel. Ask: "What is the problem?" Elicit: How does heat reach earth by radiation if there is no known medium between the sun and the earth?

    c. Tell the students that heat radiates by electromagnetic waves which are similar to the electromagnetic waves that make-up light waves and radio waves.

## SUMMARY

1. Explain how a radiator heats a room by convection.
2. "Why can't heat from a ceiling lamp reach you by conduction or convection?"
3. "How does sunlight reach the earth?"

## FOR FURTHER THOUGHT

1. Explain how heat transfer is prevented in a thermos so it can keep hot liquids hot, and cold liquids cold.
2. "In what ways are radiant heat waves, light waves and radio waves similar?" "How do they differ?"
3. "Given a candle, a match, and a nail, describe how you can demonstrate energy transfer by: (a) conduction, (b) convection, and (c) radiation."

## Lesson 4: HOW CAN WE PREVENT HEAT LOSS?

AIM: "How does a thermos bottle keep things cold or hot?"

PERFORMANCE OBJECTIVES: The students will be able to:

- apply the principles of heat transfer to methods of heat loss prevention.
- describe some characteristics of effective insulating materials.
- design an insulator.

MATERIALS: Index cards lettered B and W, Celsius thermometers, construction paper (black and white), ice, aluminum foil, newspaper, rubber bands, insulated ice buckets, lamps.

MOTIVATION: "If you go on a picnic, how do you keep your drinks cold?" Elicit: thermos, insulated bag, ice chest. "How do these things keep the drinks cold?"

### DEVELOPMENT

1. Refer to Procedure 1 on Laboratory Worksheet 2.5. Be certain that students understand that they must work in double laboratory groups. Pair up B and W groups. B groups will wrap their thermometers in black paper. W groups will wrap their thermometers in white paper. A card should be placed in each tray indicating B or W.
2. Provide a lamp (a heat lamp is best) at the front of the room for Procedure 1.
3. Guide students through all procedures on the laboratory worksheet. Have ice cubes delivered in an insulated bucket, if available (for example, styrofoam ice buckets).

### SUMMARY

1. See Laboratory Worksheet 2.5.
2. "Why is insulation important for effective calorimetry?"

### FOR FURTHER THOUGHT

1. "How can we prevent an ice cube from melting in a warm room?"
2. Suggest that students visit a store where insulation is sold. Ask: "What kinds of insulation are available?" "What are the 'R' values for the types sold?"

***NOTE TO TEACHER:** The list of some typical insulating materials which follows gives the "R" value in English Units, since this is the system used in the building trades in the United States.

# INSULATING MATERIALS

| BUILDING MATERIAL | "R" VALUE* |
|---|---|
| ASBESTOS-CEMENT BOARD | 1.73 |
| PLYWOOD (DOUGLAS FIR) | 8.66 |
| TILE AND LAY-IN PANELS, PLAIN OR ACOUSTIC | 17.33 |
| LAMINATED PAPERBOARD | 13.86 |
| HOMOGENEOUS BOARD FROM REPULPED PAPER | 13.86 |
| HARDBOARD | |
| MEDIUM DENSITY | 9.49 |
| HIGH DENSITY, SERVICE TEMP. SERVICE UNDERLAY | 8.46 |
| HIGH DENSITY, STD. TEMPERED | 6.93 |
| PARTICLEBOARD | |
| LOW DENSITY | 12.82 |
| MEDIUM DENSITY | 7.35 |
| HIGH DENSITY | 5.89 |

* R values are in SI units (m . K/W)

3. "On a cold winter day (temperature below 0°C), an ice cube placed in a metal can outside the window doesn't melt. A similar ice cube in a room at 20°C melts readily. Explain."

4. "If cold salt is place on an ice cube, the ice melts even if it is in a refrigerator at a constant temperature of 0°C. Why?"

# LABORATORY WORKSHEET 2.5

NAME________________ CLASS __________ DATE______________

PROBLEM: How can we prevent heat loss?

INTRODUCTION Heat loss can be prevented by insulation. An insulator is a material that slows or controls the flow of heat. But how does insulation work? Today you will perform a series of activities to investigate this.

MATERIALS: For each group: index cards lettered B or W, Celsius thermometer, construction paper (black and white), ice, aluminum foil, newspaper, rubber band, insulated ice bucket, lamp.

PROCEDURE

1. Insulate your thermometer.

   a. For this activity you will be working with another group. Look in your equipment tray and find the card lettered B or W. A B and a W group should work together as a pair. Select your partners.

   b. Record the room temperature, in degrees Celsius, on the chart below in the column labelled "Initial Temperature." Be sure to take readings from both the B group and the W group thermometers.

| Group | Initial Temperature | Final Temperature |
|---|---|---|
| W | | |
| B | | |

   c. Carefully wrap your thermometer bulb with the construction paper on your tray (black or white). Secure it with a rubber band.

   d. Carefully place your thermometer on the table at the front of the room under the lamp. You will come back to this later in the period.

2. Insulate the ice.

   a. Take four ice cubes from the bucket at the front of the room and place them in the pan or tray at your table.

   b. Wrap one ice cube in aluminum foil so that the dull side of the foil faces outward.

# LABORATORY WORKSHEET 2.5 (continued)

NAME ______________________________

c. Wrap one ice cube in aluminum foil so that the shiny side faces outward.

d. Wrap one ice cube in crushed newspaper and then in aluminum foil with the shiny side out.

e. Leave one ice cube unwrapped.

f. After five minutes unwrap the ice cubes and observe them.

   1. Which ice cube melted most? ____________________

   2. In step 2e above, you left one ice cube unwrapped. Explain why you were asked to do this.

   ______________________________________________________________________

   ______________________________________________________________________

3. What do we call materials that prevent heat loss? ____________________

a. Take your thermometer from the front of the table and carefully remove the insulating paper.

b. Record the temperature readings on your chart in the column marked "Final Temperature." Be sure to record both the B and the W readings.

   1. Do the initial and the final temperatures differ?
   2. Using the results of today's activities, design an efficient insulator.
   3. Why is a bulky down coat warmer than a thin woolen coat of the same mass?

SUMMARY/HOMEWORK

1. Why are substances with shiny surfaces better insulators than substances with dull surfaces?

2. Why is effective insulation important to the design of your home?

3. What are some effective insulating materials?

4. Take an inventory of the heat loss in a building such as your school. Make a list of the places from which heat is most likely to escape. Remember that heat can be lost by conduction, convection, and radiation. Recommend how you could reduce heat losses from the building and thus conserve energy.

# Lesson 5: HOW DOES HEAT CHANGE MATTER?

AIM: "How does heat cause changes to take place in matter?"

PERFORMANCE OBJECTIVES: The students will be able to:

- state that heat causes matter to expand.
- relate heat expansion of matter to an increase in the velocity of molecules.
- reason abductively (formulate hypotheses), inductively, and deductively.
- apply previously learned scientific facts and principles to explain observed demonstrations.

MATERIALS: Ball and ring apparatus, flask, rubber bands, glass tube with bulb end, colored ink, alcohol burner, tripod with wire gauze, rubber stopper, glass tube to fit one-hole rubber stopper, bimetallic strip.

MOTIVATION: Demonstrate the following (do not explain):

- Heat a flask with a balloon attached to a glass tube inserted in a one-hole rubber stopper in the flask.
- Heat the ball and ring apparatus.
- Heat the colored water that fills a flask containing a glass tube with a one-hole stopper in the neck.
- Demonstrate a bimetallic strip.

Ask: "How can we explain the changes that took place?"

DEVELOPMENT

1. Have the class write a hypothesis to answer each of the demonstrations.

2. Ask: "How can we test our hypotheses?" List suggestions on the chalkboard.

3. Repeat each of the motivation demonstrations and apply them to the hypotheses. This should lead to answering the question: "How does heat change matter?" Once the class has concluded that heat causes matter to expand, challenge the class to provide an explanation.

    a. "How are molecules related to the structure of matter?"
    b. "How are molecules related to the phenomenon of heat?"
    c. "Why does increasing heat affect the motion of molecules?"
    d. "How does this explain the demonstrations?"

4. Ask: "How does a thermostat work?"

## SUMMARY

1. "How can we use heat to do work?" (i.e., the steam engine)
2. "How does the effect of heat on matter explain why sidewalks must have spaces?"

## FOR FURTHER THOUGHT

1. "How do thermometers measure changes in heat energy?"
2. "Why do warm soda bottles explode?"
3. "Why is the Verrazano Bridge lower during the summer than it is during the winter?"

## Lesson 6: HOW DOES INTERNAL HEAT ENERGY DIFFER FROM TEMPERATURE?

AIM: "How can we determine whether an iceberg or a cup of hot water has more internal heat energy?"

PERFORMANCE OBJECTIVES The students will be able to:

- define temperature as a measure of the average kinetic energy of molecules.
- define internal heat as the total energy of a substance and describe its dependence on the amount of the substance and its temperature.
- distinguish between heat and temperature.

MATERIALS: See Laboratory Worksheet 2.6.

MOTIVATION: "Which has more internal heat energy--an iceberg or a cup of hot water?"

***NOTE TO TEACHER:** Temperature can be related to the speed at which molecules move. The faster the molecules move, the higher the temperature. Internal heat energy involves both the temperature and the amount of molecules. Therefore, a large mass at a low temperature can have more internal heat energy than a small mass at a high temperature.

DEVELOPMENT

1. Have students formulate a hypothesis about which has more internal heat energy, an iceberg or a cup of hot water.

2. Distribute Laboratory Worksheet 2.6 and guide students through the procedures.

3. Refer to Procedure 4 on the worksheet and develop a definition of internal heat energy. Elicit: INTERNAL HEAT ENERGY is the total energy possessed by a substance and depends upon the positions and the motions of molecules. It also depends upon the number of molecules involved. The amount of heat energy transferred from one object to another can be measured in units called calories.

4. Refer to Procedure 7b on the worksheet and develop a definition of temperature. Elicit: TEMPERATURE is the measure of the average motion of molecules.

5. Establish the difference between heat and temperature by referring to Procedure 7c. Elicit: Temperature is a measure of the average kinetic energy of all the particles in an object. Particles at high temperatures have more kinetic energy. Particles at low temperatures have less kinetic energy. Heat is the amount of energy transferred from one place or object to another. More heat can be transferred from a larger object than from a smaller one at the same temperature.

SUMMARY

- Refer to Laboratory Worksheet 2.6.

# LABORATORY WORKSHEET 2.6

NAME ____________________ CLASS ____________ DATE ________________

PROBLEM: How is heat different from temperature?

MATERIALS: Two styrofoam cups, two ice cubes, Celsius thermometer, stirring rod, water, beaker, graduated cylinder.

INTRODUCTION: An iceberg at 0°C contains more internal heat energy than a beaker of boiling water at 100°C. Today you will discover why.

PROCEDURE

1. Using the graduated cylinder, measure 30 ml of warm water and pour it into a styrofoam cup. Label this Cup No.1.
2. Using the graduated cylinder measure 100 ml of warm water and pour it into the second styrofoam cup. Label this Cup No.2.
3. Record the thermometer reading of the water in each cup on the data table below:

| | Initial Temp | Final Temp | Change in Temp |
|---|---|---|---|
| Cup No.1 | | | |
| Cup No.2 | | | |

4. Place an ice cube into each cup.
5. Stir the water in Cup No. 1 until the ice melts. Measure and record the temperature.
6. Stir the water in Cup No. 2 until the ice melts. Measure and record the temperature.
7. Complete the data table by determining and recording each temperature change.
    a. How did the temperature change in Cup No.1? Compare with the temperature change in Cup No.2.

# LABORATORY WORKSHEET 2.6 (continued)

NAME ______________________________

b. How can we explain the difference between the two temperature changes?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

c. How is the amount of water related to the amount of heat that was transferred in each cup?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

SUMMARY/HOMEWORK

1. What is the difference between internal heat energy and temperature?
2. Why does an iceberg at 0°C contain more internal heat energy than a beaker of boiling water?

# ADDITIONAL IN-CLASSROOM ACTIVITY

1. Why are students seated near a sunny window getting more heat than those sitting near the door?

2. Write a report on early theories of heat and its behavior. Choose one of the following scientists:

    a. Sir Humphrey Davy
    b. Antoine Lavoisier
    c. Benjamin Thompson (Count Rumford)

3. Does an ice cube have internal heat energy? Explain.

4. How does additional heat make objects larger?

ESSENTIAL VOCABULARY

1. distribute
2. comfort
3. apparent
4. convection
5. absorb
6. conduction
7. radiation
8. calorimeter
9. insulation
10. internal heat energy

# Lesson 7: HOW IS HEAT MEASURED?

AIM: "Which is more fattening, an apple or a cheeseburger?"

PERFORMANCE OBJECTIVES: The students will be able to:

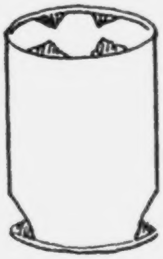
- use a calorimeter set-up to measure the heat given off by a burning candle.
- demonstrate specific, manipulative skills in a laboratory activity, such as handling graduated cylinders, heating water, and reading a thermometer.
- determine volume and mass.

MATERIALS: See Laboratory Worksheet 2.7.

MOTIVATION: "Which is more fattening--a cheeseburger or an apple?" "What kind of equipment will enable us to determine which one is more fattening?"

DEVELOPMENT

1. If no bomb-type calorimeters are available in the school, have students bring in empty cans from soup and/or canned vegetables. Prepare a calorimeter heater by punching four holes in the sealed end of the can (a beer can opener should be used), and two holes as vents near the open end. (Once the heaters have been prepared, they can be used from year to year.)



2. Ask: "What is a calorie?" (Although the joule and the calorie are both units of energy and use of the joule is generally preferred by scientists, we will use the familiar calorie for ninth grade science. A calorie may be defined as the heat necessary to increase the temperature of one gram of water from 15.5° C to 16.5°C. As defined above, one calorie is equal to 4.184 joules. For this course, we will define a calorie more simply, as the heat needed to raise the temperature of 1 gram of water by 1°C.)

3. The size of the beaker should be such that it fits exactly on top of the tin can heater. Adjust beaker size accordingly.

4. Guide students through procedures on Laboratory Worksheet 2.7. If you use a commercial bomb-type calorimeter, the following procedure may be followed.

   a. Mass out 25 grams of water at 20°C.

   b. Place in a calorimeter and heat to 30°C.

   c. To determine how much heat is absorbed:

      1. amount of heat transferred (calories) = mass of water (grams) x change in temperature (°C)
      2. temperature change = final temperature minus initial temperature (30°C - 20°C = 10°C)
      3. $\Delta H = M \times \Delta T$

## SUMMARY

. See Laboratory Worksheet 2.7.

## FOR FURTHER THOUGHT

1. "During your experiment, some of the heated water evaporated from the calorimeter. How might this loss of water have affected your results?"

2. "Go to the library and find a picture of a commercial calorimeter. How does this calorimeter compare with your 'homemade' one?" "Is it more accurate?" "Why?"

# LABORATORY WORKSHEET 2.7

NAME____________________________ CLASS__________ DATE____________________

PROBLEM: How is heat measured?

INTRODUCTION: Heat energy is measured in units called calories. A calorie is the amount of heat that must be transferred to raise the temperature of one gram of water by one degree Celsius. Today we will be using a tin can calorimeter, which is an instrument used to measure heat.

MATERIALS: Celsius thermometer, candle, tin can calorimeter, 250 ml beaker, triple beam balance, water, graduated cylinder, ceramic (or other material) pads, tongs.

PROCEDURE

1. Calculate the total heat energy that can be produced by burning a paraffin candle.

   a. A candle produces approximately 10,000 cal/g. when it burns

   b. Using the triple beam balance determine the mass of your candle (in grams). ____________g.

   c. The total energy your candle can produce is __________ calories.

2. Measure the heat energy coming from your candle.

   a. Using the graduated cylinder, measure 25 milliliters of water and pour it into your beaker. The water mass is_______________g.

   b. Determine the temperature of the water in the beaker. _________°C

   c. Shape the clay at your table into a candle holder by pressing the bottom of the candle into it. Place on a ceramic pad.

   d. Making sure that the candle is firm in its holder, light it and CAREFULLY lower the tin can calorimeter over the lighted candle.

   e. Place the beaker with water on top of the tin can. Hold the thermometer in the beaker and allow the water to heat for five minutes. The water temperature at the end of five minutes is ______________°C.

   f. Quickly and carefully:

      1. Remove the thermometer.
      2. Move the beaker to a ceramic pad on your desk.
      3. Lift the tin can with your tongs.
      4. Blow out the candle.

   g. Remass your candle. Its mass is now______________g.

# LABORATORY WORKSHEET 2.7 (continued)

NAME ______________________

SUMMARY/HOMEWORK

1. Do the arithmetic.

   a. The heat from the candle caused a change of ______ °C in the water.

   b. Calculate the amount of heat absorbed by the water. ______ calories

      Heat (calories) = mass of water (g) x change of temperature (°C)

   c. The heat energy given off by the candle is equal to ______ calories.

      (Calories of candle wax = change in mass of candle x ______ cal/g)

2. Why is the number of calories given off by the candle greater than the number of calories absorbed by the water?

# Lesson 8: HOW DO WE USE HEAT ENERGY?

[OPTIONAL]

AIM: "How is your home heated?"

PERFORMANCE OBJECTIVES: The students will be able to:

- apply their knowledge of the characteristics of heat energy to the design of home heating systems.

MATERIALS: None.

MOTIVATION: "How many of you live in apartment buildings?" "How do people who live on high floors of buildings get heat in the winter?" Elicit the need to transfer heat from the source.

DEVELOPMENT

1. Ask: "How does a fireplace heat a room?" Review principles of conduction, convection, and radiation. Ask: "Why is it inefficient?"

2. "How could a central heating system overcome some of the inefficiencies of the fireplace?"

   - Elicit the idea of a single centralized "fireplace."

   Ask: "How could the heat energy from this central fire be transferred to all the rooms in a house?"

   - Elicit the need for a medium of heat transport and a system to circulate this medium, i.e., water, steam or hot air circulated through radiators and/or grids.

   - Develop a diagram to represent the system designed by the class.

3. Explain how energy in fuel is used to heat a home:

   "Heat released from burning fuel can be transferred in three ways. Some heat passes by rays into the surrounding space. This type of heat transfer is called radiation. You can feel it on your hands and face when you are near an electric heater. Heat can also be carried through metal objects. This method of heat transfer is called conduction. A third method by which heat can be carried uses moving air or water. This is called convection. All home heating systems use one or more of these methods."

5. Ask: "How does the efficiency of your heating system depend upon the structure and insulation?"

## SUMMARY

1. "How is the boiler of a central heating system like a fireplace?"
2. "Why is it more important to insulate the roof of a home than the walls?"

## FOR FURTHER THOUGHT

1. "Why is a radiator usually placed at floor level?"
2. "How does insulation save energy?"
3. "Explain how the three types of heat transfer (conduction, convection, radiation) are used in a forced hot water heating system."
4. "Write a report on how cooling systems are similar to heating systems."

# Theme II — Questions for Review

Unit 2. Heat on Earth

NAME______________________________ CLASS__________ DATE ____________________

1. Temperature is measured in a unit called a:
   - a. gram
   - b. calorie
   - c. degree
   - d. liter

2. Heat can cause changes in:
   - a. length
   - b. temperature
   - c. molecular motion
   - d. all of these

3. Energy from the sun reaches the earth by:
   - a. conduction
   - b. convection
   - c. radiation
   - d. all of these

4. When a body is heated, the molecules:
   - a. contract
   - b. move more slowly
   - c. move faster
   - d. move closer together

5. The rising column of smoke from a smokestack is mainly due to:
   - a. conduction
   - b. convection
   - c. radiation
   - d. induction

6. Solids transfer heat by the process of:
   - a. conduction
   - b. convection
   - c. radiation
   - d. induction

7. Directly or indirectly, most of our heat comes from:
   - a. electricity
   - b. chemical energy
   - c. the sun
   - d. mechanical energy

8. A thermostat uses the property of:
   - a. radiation
   - b. expansion
   - c. color
   - d. potential energy

NAME________________________________________

9. A steel building is taller in summer than in winter because:
    a. the building has more particles in the summer
    b. the spaces between its particles have become smaller
    c. the spaces between its particles have become greater
    d. its particles move more slowly in summer

10. Heat always moves from places of high temperature to places:
    a. of higher temperature
    b. of lower temperature
    c. with the same temperature
    d. none of the above

11. The number of calories needed to raise the temperature of 3 grams of water by 2°C is:
    a. 1 calorie
    b. 1.5 calories
    c. 5 calories
    d. 6 calories

12. When heat energy is absorbed by a gas, it is transformed to:
    a. potential energy
    b. light energy
    c. electrical energy
    d. kinetic energy

13. When a brass ball is heated in a flame, it:
    a. remains unchanged
    b. expands
    c. contracts
    d. melts

14. Expansion is caused by:
    a. an increase in the size of the molecules
    b. a decrease in the size of the molecules
    c. a decrease in the distance between molecules
    d. an increase in the distance between molecules

15. If an aerosol can is placed in an incinerator it is likely to:
    a. contract
    b. melt
    c. not be affected
    d. explode

NAME________________________________________

## Matching

Column A

16. Object or material that prevents conduction

17. Energy transfer by the movement of a large mass of liquid or gas

18. Measure of the average kinetic energy of particles of matter

19. Transfer of energy as waves

20. Energy transfer by contact between particles

Column B

a) radiation

b) conduction

c) convection

d) insulator

e) temperature

## Explain the Following

21. To ventilate a room properly, you should open its windows at both the top and bottom.

22. Use the kinetic theory to explain how the end of a spoon you are holding becomes hot when the other end is in a pot of boiling water.

23. What is the difference between heat and temperature?

24. How does a thermostat work?

25. Given a candle, a match, and a nail, describe how you could demonstrate transfer of heat energy by a) conduction, b) convection, c) radiation.

## Multiple Choice

26. A cold metal spoon is placed into a cup of hot coffee. This results in:
    a. increased motion of the water molecules in the cup
    b. increased molecular motion of the spoon's molecules
    c. production of radiation
    d. absolutely no effect on either the spoon or the coffee

27. Lynette had an iron rod and a copper rod. They were of equal lengths, and each had a small piece of wax at its tip. The unwaxed end of each metal rod was placed into a flame and each rod received equal amounts of heat. The wax on the copper rod began to melt first because:
   a. the copper rod was probably closer to the flame
   b. iron is a better heat conductor than copper
   c. copper is a better heat conductor than iron
   d. Lynette introduced too many variables into her procedures

28. An uninflated balloon is placed on top of a flask. The flask is heated. The balloon will:
   a. expand
   b. deflate even more
   c. remain unchanged
   d. not absorb any heat, since rubber is an insulator

29. A convection box has two glass chimneys. One chimney is above a candle. Lighting the candle causes the air above the candle to:
   a. expand
   b. become part of a convection current
   c. rise
   d. all of the above

30. Heat from a ceiling lamp reaches the ground by:
   a. convection
   b. conduction
   c. radiation
   d. the creation of energy

Questions 31-35 are based upon the following:

Denise had a ball and ring apparatus. She fit the ball through the ring. The next day she attempted to fit the ball through the ring, but was unsuccessful.

31. The ball didn't fit through the ring the second day because:
   a. the ball might have expanded
   b. the ring might have gotten smaller or contracted
   c. the ball might have been affected by heat
   d. all of the above

32. If Denise had heated the ball:
   a. its molecules would have moved closer together
   b. its molecules would have been unaffected
   c. its molecules would have moved farther apart
   d. the molecular motion would have decreased

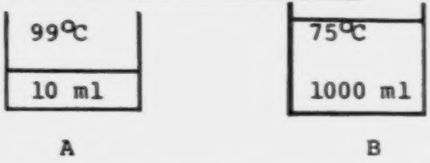
33. If Denise had heated the ball, its molecules would have:
   a. moved more rapidly
   b. moved more slowly
   c. contracted
   d. been unaffected

34. When most solids are cooled, their molecules:
   a. move farther apart
   b. move closer together
   c. expand
   d. are unaffected

35. The ball and ring apparatus represents:
   a. solids and their reaction to heat
   b. liquids and solids and their reaction to heat
   c. gases, liquids, and solids, and their reactions to heat
   d. air and its reaction to heat

36. Small spaces are left between sections of railroad track because:
   a. pressure on the wheels must be relieved
   b. it's a tradition from the railroad's early history
   c. solids expand when heated and leaving spaces prevents problems
   d. all of the above

Questions 37 - 42 are based upon the following:



37. The water at the higher temperature is in beaker:
   a. A
   b. B
   c. The beakers contain water at the same temperature.

38. Water molecules are moving faster, on average, in beaker:
   a. A
   b. B
   c. The water molecules in the two beakers are moving at the same average rate.

39. The greater volume of water is in beaker:
   a. A
   b. B
   c. The beakers contain equal volumes of water.

40. More internal heat energy is possessed by the water molecules in beaker:
   a. A
   b. B
   c. The water molecules in the two beakers have equal amounts of energy.

41. More ice could be melted by the water in beaker:
   a. A
   b. B
   c. The water in the two beakers could melt equal amounts of ice.

42. More internal heat energy is present in the water in beaker:
   a. A
   b. B
   c. There are equal amounts of heat in the water in the two beakers.

# UNIT 3. I SEE THE LIGHT

## Lesson 1: WHAT ARE SOME CHARACTERISTICS OF LIGHT?

AIM: "Why can't we all see the candle light?"

PERFORMANCE OBJECTIVES: The students will be able to:

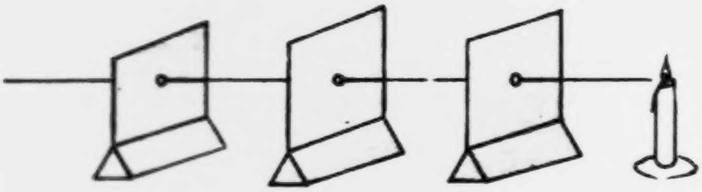
- identify light as a form of energy.
- explain that when light is blocked by opaque objects, shadows are produced.
- conclude that light travels in straight lines.

MATERIALS: Radiometer, point source of light, rubber band, ping-pong ball, string, screen.

MOTIVATION: Display a radiometer. Have the students describe it. Shine a light on it, or place it in sunlight. Ask: "What causes the vanes to turn?" Elicit that light is a form of energy.

DEVELOPMENT

1. Demonstrate that light travels in straight lines. Use the illustration that follows or shine a light down one row in the classroom. Ask: "Why can't a person sitting at the far end of the row see the light?"



2. "How does an opaque object affect transmission of light?" Elicit that opaque objects completely block light. When light strikes an opaque object, the light is blocked and a shadow may be formed behind the object.

3. Direct a cone of light from a point source onto a screen. This can be done with the aid of a penlight or a small high-intensity lamp. Now, suspend a ping-pong ball between the light and the screen. Have the class describe the shadow produced. (A completely dark shadow should be observed on the screen.)

4. Repeat the above procedure, but use an extended light source, such as an ordinary light bulb. Have the students describe what they observe. The shadow formed should consist of two areas, an UMBRA or a dark central portion, and a PENUMBRA or lighter shadow surrounding the umbra.

5. Ask: "Why does a penumbra form?" The students should explain that the penumbra receives some light from the edges of the extended source, but the umbra receives NO light.

6. Ask: "How do the demonstrations that you have seen today indicate that light travels in straight lines?"

7. Demonstrate a radiometer rotating in a light beam and show how sunlight concentrated with a magnifying glass can be focussed to burn paper. Then ask: "How can we use light to do work?"

## SUMMARY

1. "Why is light defined as a form of energy?"

2. "Why is sunlight called the source of most other forms of energy?"

## FOR FURTHER THOUGHT

1. "What is a laser?"

2. "How are lasers used in industry and medicine?"

## Lesson 2: HOW CAN A LIGHT RAY BE BENT?

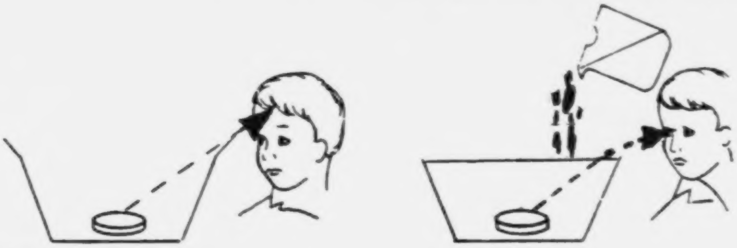
AIM: "What caused the hidden coin to reappear?"

PERFORMANCE OBJECTIVES: The students will be able to:

- define refraction as the bending of a light ray as it passes from one medium to another.
- explain why refraction takes place.
- relate the focusing of light by lenses to a change in light speed.
- reason inductively and deductively.

MATERIALS: Battery jar, small beaker (25 ml), coin.

MOTIVATION: Place a coin in a cup with opaque sides so that it cannot be seen. Slowly add water. The coin appears to rise until it becomes visible. Challenge the class to explain.



*HINT FOR THE TEACHER

The coin cannot be seen because the light is blocked by the sides of the cup. Adding the water makes the light bend. When the bent light enters a student's eye, the coin becomes visible. The bending of light makes the coin appear to be in a different position than it is actually in.

DEVELOPMENT

1. Have students attempt to toss coins into a small glass or beaker placed inside a battery jar filled with water. Ask: "Why is this harder to do than it looks?" "How is it related to the 'appearing coin' demonstration?"

2. Ask: "What are some other examples of water bending light?"

    a. It is difficult to pick up soap in the tub.
    b. A swimmer coming to the surface appears to have a detached head.

3. Ask: "What causes the bending of light?"

    REFRACTION: the bending of light when it passes at a slant from one transparent material into another. It takes place because the speed of light is different in different media.

    air -- 186,000 miles/sec ($3 \times 10^8$ meters/sec)
    water -- 140,000 miles/sec ($2.75 \times 10^8$ meters/sec)
    clear glass -- 124,000 miles/sec)

4. Ask: "How can we use this information to explain how lenses work?" Elicit: A lens is a piece of transparent material having at least one curved surface. Although lenses differ in size, shape and substance, the chief purpose of all lenses is to refract light. The amount of refraction produced by a lens depends both upon its shape and the speed of light in the substance of which the lens is made.

### THE SPEED OF LIGHT IN DIFFERENT MEDIA

| Medium | Speed (meters per second) |
|---|---|
| vacuum | 299,792,500 |
| air | 299,700,000 |
| methyl alcohol | 228,000,000 |
| water | 226,000,000 |
| quartz | 207,000,000 |
| benzene | 200,000,000 |
| ordinary glass | 198,000,000 |
| sodium chloride* | 195,000,000 |
| ethyl alcohol | 188,000,000 |
| heat-resistant glass | 181,000,000 |
| diamond | 124,000,000 |

*clear salt crystals

## SUMMARY

1. "Explain why water always appears to be more shallow than it actually is."
2. "How is light affected by lenses?"
3. "Why are light rays refracted when they pass through a gas into a solid?"

# Lesson 3: HOW DO LENSES FOCUS LIGHT?

AIM: "How can using a lens produce a fire?"

PERFORMANCE OBJECTIVES: The students will be able to:

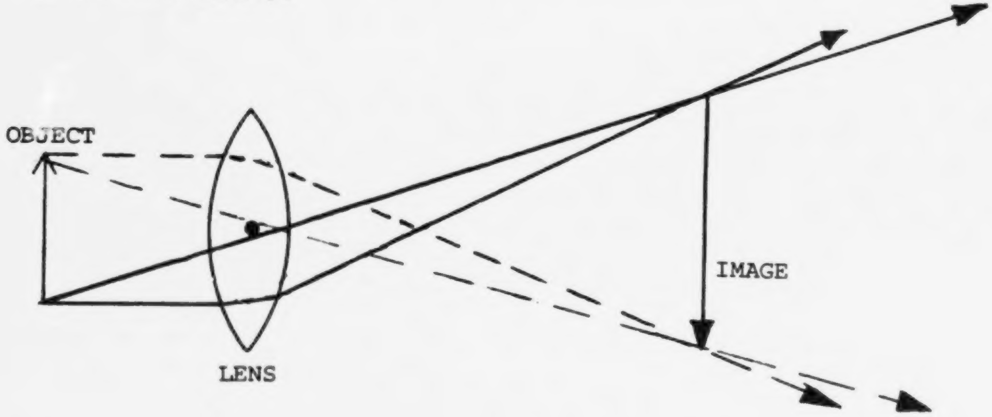
- describe how convex and concave lenses focus light.
- illustrate the behavior of light as a result of passing through convex and concave lenses.

MATERIALS: Optical bench (sliding lens on a meterstick), convex and concave lenses, screen, chalkboard optics.

MOTIVATION: "Wayne, Stanley, and Sam were on a camping trip one sunny day. They lost their matches and wanted to start a fire. Wayne looked at his wristwatch and said, 'I can start the fire with my watch.'" Ask the students to explain how Wayne was going to do this. Elicit that the watch lens could act like a converging lens.

DEVELOPMENT

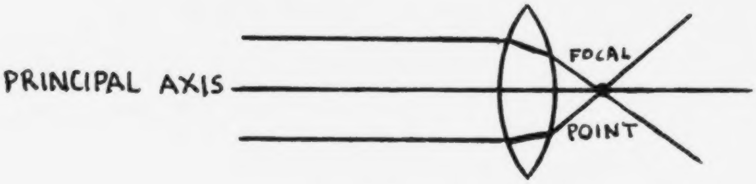
1. Distribute convex lenses to the students (one lens to each group of four or five students).



2. Ask: "How does the convex lens pictured above affect light passing through it?" Elicit: In a convex lens, the surface of the lens is curved so that the edges are thinner than the center. A convex lens converges light.

3. Develop the concept that a convex lens brings all the light rays together. The point at which they meet is called the FOCUS or FOCAL POINT. Refer to the above diagram and point out the location of the FOCUS or FOCUS POINT.

4. Draw the following on the chalkboard:



Explain that the principal axis is that line which is perpendicular to the plane of the lens. Light passing through the lens along the principal axis is not bent, but parallel rays of light passing through other parts of the lens are bent toward a focal point.

5. Have the students observe the image of an electric lamp formed by the convex lens on a screen.
    a. Ask: "Why is the image upside down?" Show how light rays that emanate from the top of the bulb are focussed at the bottom of the screen and how light from the bottom of the bulb is focussed at the top of the screen.
    b. Change the distance between the bulb and the lens and relocate the screen so a sharp image reappears. Have students observe how the size of the image changes with different object distances.

6. Distribute concave lens. Explain that it is thinner in its center than at its edges. This lens spreads light rays apart. The image formed by such a lens appears right side up.
    a. Ask: "How does a concave lens differ from a convex lens?"
    b. Ask: "Why is the image larger than the object?"
    c. Illustrate the working of a concave lens on the screen. Discuss virtual images and compare them to mirror images.

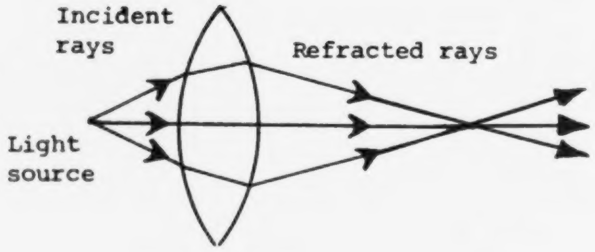
SUMMARY

1. "How is it possible for a slide or movie projector with a converging lens to produce an image that appears to be erect on the the screen?"

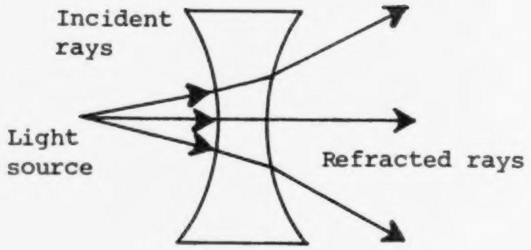
2. "How can the projected image on the screen be made smaller or larger for different size screens?"

FOR FURTHER THOUGHT

- "Explain how a refracting telescope works."


Incident
rays
Refracted rays
Light
source

CONVEX LENS


Incident
rays
Light
source
Refracted rays

CONCAVE LENS

# Lesson 4: WHAT IS THE COMPOSITION OF WHITE LIGHT?

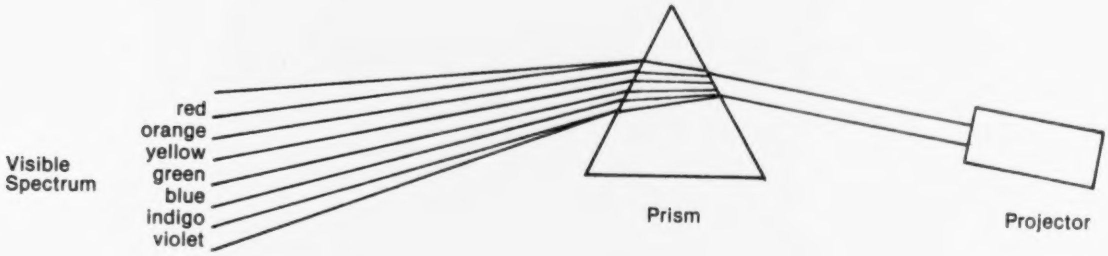
AIM: "What causes the colors in a prism?"

PERFORMANCE OBJECTIVES: The students will be able to:

- identify a specific problem for a given situation.
- comprehend that a prism will disperse white light into its component colors.
- apply the principle of refraction to explain the formation of a rainbow.

MATERIALS: Light source such as a slide or movie projector, prism, screen.

MOTIVATION: Using the light source and prism, demonstrate how white light is separated into the spectrum. Elicit from the students the question: "How can we explain the appearance of the colors?"



DEVELOPMENT:

1. Have the students trace the path of the light beam through the prism.
    a. Ask: "How does the prism affect the light beam?" Elicit that the prism bends or refracts the light beam.
    b. Ask: "How do you know that the colors cannot be emitted from the prism itself?" Elicit that the prism is non-luminous and so it could not be adding color to the white light.
    c. Guide the students to conclude that white light is made of different colors combined. Each color bends a different amount of light when it passes through the prism.

2. Ask the students to identify the sequence of colors that appears on the screen when the prism is held base down. Elicit RED, ORANGE, YELLOW, GREEN, BLUE, INDIGO, VIOLET. (R. O. Y. G. B. I. V. or ROY G. BIV)

    Ask: "Why is the order of colors reversed when the prism is held base upward?" The students should realize that red undergoes the least refraction and violet the greatest. The order of appearance is determined by the orientation of the prism.

3. Ask: "What causes a rainbow?" Lead the students to explain that rainbows may appear after rainstorms when water droplets are suspended in the air. Depending upon the cloud conditions, each water droplet has the potential to act as a small prism with a mirror behind the prism to reflect the light toward the earth.

## SUMMARY

1. "How can you demonstrate that white light is composed of different colors?"
2. "Why can a prism separate white light into different colors?"
3. "Why can't a prism produce a rainbow of colors from a red light source?"

# Lesson 5: HOW DO MIRRORS DIFFER FROM LENSES?

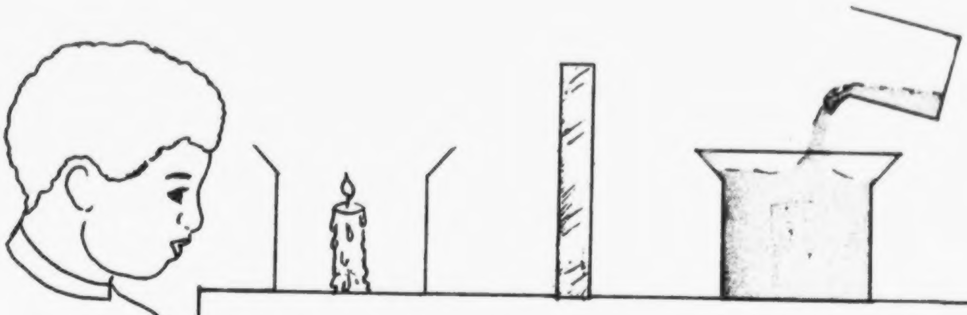
AIM: "Is the candle really burning?"

PERFORMANCE OBJECTIVES: The students will be able to:

- construct a plane mirror.
- compare the characteristics of a mirror to the characteristics of a lens.

MATERIALS: See Laboratory Worksheet 2.8.

MOTIVATION: Show a magic trick--a candle burning under water.



If the rear beaker is as far in back of the glass plate as the front beaker is in front of it, the two beakers will look like one from the front. Light the front candle, then pour water into the rear beaker. It will seem to the students that the candle is burning under water. This is also a very fine way to show that in a plane mirror, the image is as far in back of the mirror as the object is in front of the mirror.

## DEVELOPMENT

1. Distribute Laboratory Worksheet 2.8 and guide students through it. Make certain that the aluminum foil is smooth.

2. Explain that a smooth surface that reflects light is a mirror. Mirrors having flat surfaces are called plane mirrors. Mirrors produce a virtual image. The image will seem to be flipped over from left to right. When light is reflected from a plane mirror, the pattern of light rays is reversed. The rays appear to be folded over.

   All mirrors obey the law of reflection. (The angle of incidence is equal to the angle of reflection.)

## SUMMARY

- See Laboratory Worksheet 2.8.

# LABORATORY WORKSHEET 2.8

NAME______________________ CLASS __________ DATE____________

**PROBLEM:** How do mirrors differ from lenses?

**INTRODUCTION:** An image is produced by a lens when the rays of light pass through the glass of the lens. An image is produced by a mirror because the rays of light cannot pass through it. Today you will construct a mirror from a lens to see why this is true. You will also be studying the mirror reflections to learn the characteristics of these images.

**MATERIALS:** Aluminum foil, flat piece of glass, convex lens, plane mirror.

**PROCEDURE**

1. Study the flat piece of glass on your table.

   a. How does the shape of this differ from that of convex and concave lenses?

   ______________________________________________

   b. Hold the glass up toward the window and look through it. Describe what you see.

   ______________________________________________

   c. How do we know that light must travel through the glass?

   ______________________________________________

2. Study your reflection in the sheet of aluminum foil on your table. Why is this said to have a mirror surface? DRAW A DIAGRAM ON THE BACK OF THIS LABORATORY WORKSHEET PAGE TO EXPLAIN YOUR ANSWER.

   a. Hold the foil up towards the window. What do you observe looking through the foil?

   ______________________________________________

   b. Why doesn't the light from the window pass through the foil?

   ______________________________________________

   c. What happens to the light rays that do strike the foil?

   ______________________________________________

# LABORATORY WORKSHEET 2.8 (continued)

NAME ______________________

d. Using the foil and the flat piece of glass, construct a conventional mirror. Why is this a better mirror surface than foil alone?

## A MIRROR IMAGE

1. Study the commercial mirror on your table. Why are its reflections CLEARER than those seen on your homemade mirror?
2. Try to touch your image on the surface of the mirror. Are you able to reach your image?
3. Move the mirror closer to you. Now move it away. What happens to the distance between you and your image? (Study the mirror carefully as you move it.)
4. How far behind the mirror does the image appear to be?
5. Move the mirror to the left. Now move it to the right. While looking into the mirror, move yourself to the left. Now move to the right. In what direction does the image move in each case?
6. From what you have done so far, describe the MIRROR IMAGE.

## SUMMARY/HOMEWORK

1. How are distortions created in a hall of mirrors?
2. What is meant by the term "mirror image"?

## Lesson 6: HOW ARE MIRRORS USED?

AIM: "How is a shiny spoon like a mirror?"

PERFORMANCE OBJECTIVES: The students will be able to:

- discover the properties of plane, convex, and concave mirrors.
- apply these properties to a variety of commonly used items.

MATERIALS: See Laboratory Worksheet 2.9.

MOTIVATION: "How are mirrors used?"

DEVELOPMENT

1. Distribute Laboratory Worksheet 2.9 and guide students through it.
2. State that a mirror that curves inward is a concave mirror. The size of the image that a concave mirror forms depends upon how far the object is from the mirror. It can be a real or a virual image.
3. Explain that a mirror that curves outward is a convex mirror. This type of mirror diverges light rays by reflection. A convex mirror always forms small virtual images.

SUMMARY

- See Laboratory Worksheet 2.9.

# LABORATORY WORKSHEET 2.9

NAME______________________ CLASS__________ DATE______________

**PROBLEM:** How are mirrors used?

**MATERIALS:** Shiny metal spoon.

**INTRODUCTION:** Mirrors have many uses in the home, stores, and vehicles. They play an important role in our daily activities. The interaction between light and mirror follows definite laws of science. Today we will reflect on mirrors and their uses and properties.

**DEVELOPMENT**

1. How does the spoon resemble a pocket mirror?

______________________________________________

______________________________________________

2. Study the rounded back of the spoon.

    a. Why can you see yourself reflected here?

    ______________________________________________

    b. Describe your image in the spoon.

    ______________________________________________

    c. How does this image differ from one you see in a PLANE mirror?

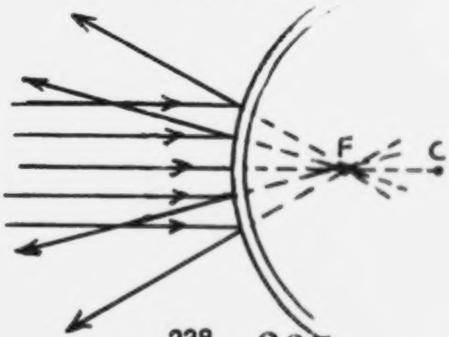
    ______________________________________________

    d. How do you know that this side of the spoon's surface is a CONVEX reflecting surface?

    ______________________________________________

    e. Study the image formed in the large convex mirror. Then study the diagram below:

CONVEX MIRROR



## LABORATORY WORKSHEET 2.9 (continued)

f. Why does a convex mirror always make an image that is smaller than the object?

g. How are convex mirrors used on autos?

How do they help prevent shop lifting in large stores?

h. What are some other uses of convex mirrors?

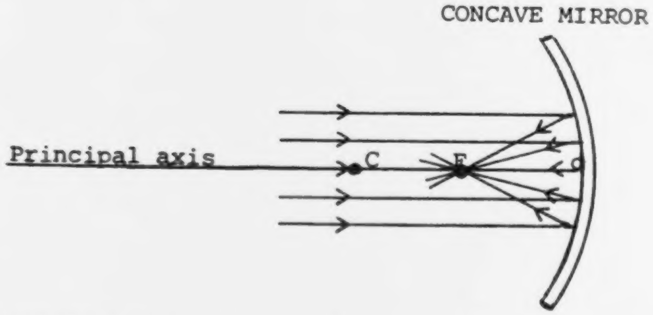
3. Study the bowl of the spoon.

a. Turn the spoon around and compare the images formed on the convex back surface and in the bowl. How does your bowl image differ from that formed on the convex back? Which image is larger? Which is inverted?

b. Why is the spoon bowl called a CONCAVE reflecting surface?

c. How does your image in the bowl differ from that seen in a PLANE mirror?

d. Study the diagram below:



e. Explain how a concave mirror can sometimes make the image appear larger than the object.

# LABORATORY WORKSHEET 2.9 (continued)

f. Design a telescope (on the back of this laboratory worksheet page) that uses a concave mirror instead of a lens.

g. What are some other uses for concave mirrors?

4. Make a drawing of a mirror that is part concave and part convex. Draw an object and the image formed by such a mirror.

Where have you seen mirrors of this type? ____________________

5. What are some other uses for plane mirrors? Why do home decorators often place large mirrors in dimly lit rooms?

6. Make a list of optical instruments that might use mirrors instead of (or in addition to) lenses.

SUMMARY/HOMEWORK

. Why do some reflecting telescopes use both concave and plane mirrors?

# Lesson 7: HOW CAN WE CONSTRUCT A TELESCOPE?

[OPTIONAL]

AIM: "How can we construct a refracting telescope?"

PERFORMANCE OBJECTIVES: The students will be able to:

- construct a telescope from two convex lenses.
- describe the light-gathering process of telescope lenses.
- view and describe the image seen through a telescope.

MATERIALS: See Laboratory Worksheet 2.10.

MOTIVATION: "How do we know that there are rings around the planet Saturn?"

## DEVELOPMENT

Suggestions to teachers:

1. To promote understanding of the principles and mechanisms involved in the operation of the telescope, the actual planning and construction should be extended over a two-day period. If you split the lab exercise, do 1A, 1B, and 1C the first day; the rest of the lab the second day.

2. Refer to procedure 4 on Laboratory Worksheet 2.10. Students might have some difficulty measuring the focal length of the lens. It is suggested that this activity be done by all groups in unison and be directed by the teacher.

* **NOTE TO TEACHER:** In procedure 4 on the worksheet, caution the students not to focus sunlight on white paper because the paper may catch fire. For best results, have students select distant objects such as trees or houses seen through a window. The focal length of the lens is the distance between the lens and a screen on which the image is in sharp focus.

## SUMMARY

- See Laboratory Worksheet 2.10.

## FOR FURTHER THOUGHT

1. "Compare a telescope with a microscope."

2. "What is the difference between a reflecting telescope and a refracting telescope?"

# LABORATORY WORKSHEET 2.10

NAME________________________________ CLASS__________ DATE________________

**PROBLEM:** How can we construct a refracting telescope?

**INTRODUCTION:** Spotting telescopes are instruments used to bring far-off objects into close view. The properties of light and lenses are used to focus and enlarge objects too distant for detailed study with the unaided eye. Today you will be assemble such an instrument. See if you can discover how and why your telescope works.

**MATERIALS:** Meterstick with desk stands, 15 cm focal length glass lens, 30 cm focal length glass lens, screen, screen holder, two lens holders.

**PROCEDURE**

I. Before you begin:

A. Examine the lenses you have been given. These are called converging lenses. Describe their surfaces and draw a diagram.

________________________________________

________________________________________

________________________________________

________________________________________

B. Hold up one lens so that light passes through it to your eye.

1. How does it affect your view? ____________________

________________________________________

2. How does the view change as you move the lens closer to your eye?

________________________________________

3. Look at both lenses. How do they differ from each other?

________________________________________

C. How does the view change as you move the lens away from your eye?

________________________________________

# LABORATORY WORKSHEET 2.10 (continued)

NAME ______________________________

II. Constructing your telescope.

- A. Mount the meterstick on the stands.
- B. Mount the screen near the center of the meterstick.
- C. Using a lens mount, place one lens on the meterstick in front of the screen.

III. Select a fairly large and distant object, such as a tree or house outside the classroom window. Move your lens back and forth until you see the clearest possible picture of the object on your screen.

- A. How does the image on the screen resemble the original object?

  ______________________________________________________________________

  ______________________________________________________________________

- B. Describe how the image differs from the original object and draw a diagram.

  ____________________________________________

  ____________________________________________

  ____________________________________________

- C. Carefully measure and record the distance between the screen and the lens. This distance is the focal length of the lens.

  Focal length of the lens is __________ cm.

IV. Replace lens 1 with lens 2. Repeat the same procedure with lens 2 placed at the opposite end of the meterstick.

Focal length of second lens is __________ cm.

V. Now place both lenses at the proper focal lengths on opposite sides of the screen. Observe the object on the screen through the lens with the small focal length.

VI. Without touching the lenses, remove the screen from the stick and look through the eyepiece. Describe what you see.

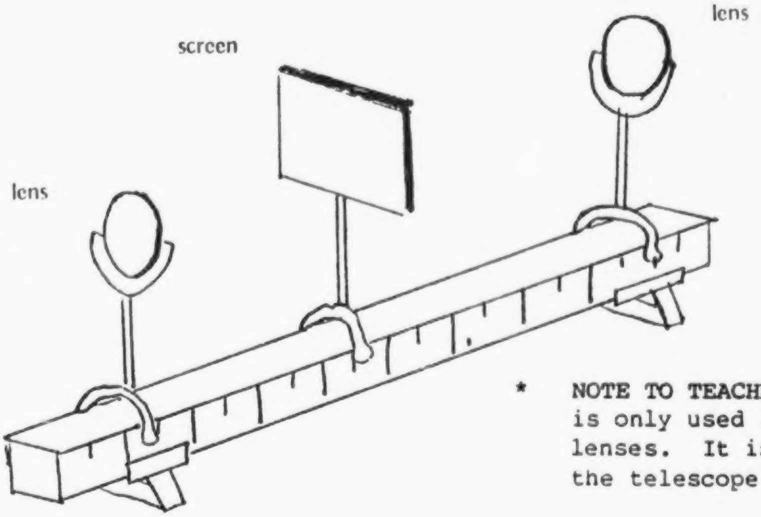
______________________________________________________________________

______________________________________________________________________

# LABORATORY WORKSHEET 2.10 (continued)

NAME ____________________

VII. Turn your telescope around and use the eyepiece lens as the objective lens. Describe how the image changes and draw what you see.



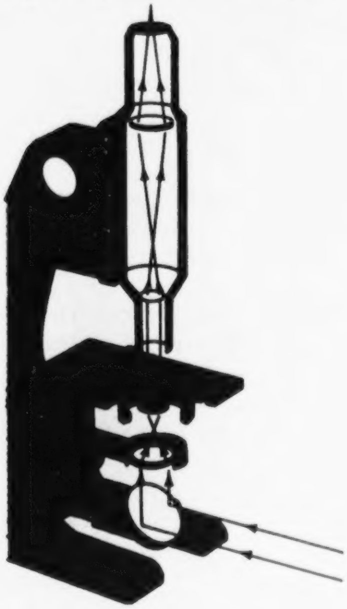
* **NOTE TO TEACHER:** The screen is only used in focusing the lenses. It is removed to use the telescope.

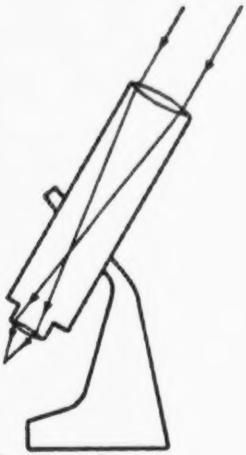
SUMMARY/HOMEWORK

1. Why are two lenses used in the construction of the telescope?
2. What happens when you move the two lenses closer together?
3. What happens when you move the two lenses farther apart?
4. Why do we use a telescope to observe distant objects?
5. Why are the lenses of the telescope enclosed in a tube?

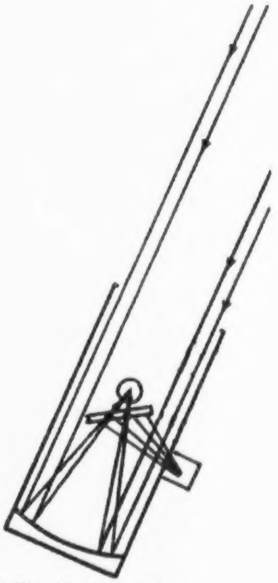
# LABORATORY WORKSHEET 2.10 (continued)

Light rays in a microscope





Refracting telescope



Reflecting telescope

Jay M. Pasachoff, Naomi Pasachoff, and Timothy M. Cooney, Physical Science (Glenview, Ill.: Scott, Foresman and Co., 1983), pp. 357-358.

## Lesson 8: HOW DO WE KNOW THAT THERE IS INVISIBLE LIGHT?

AIM: "What causes the minerals to glow?"

PERFORMANCE OBJECTIVES: The students will be able to:

- identify the parts of the electromagnetic spectrum.
- cite evidence for the existence of invisible light.
- describe how invisible light is used.

MATERIALS: Prism, chart or transparency of electromagnetic spectrum (overhead projector), fluorescent minerals, X-ray photograph, white light source, ultraviolet light source.

MOTIVATION: Have students list all sources of "light" that come into the room. Remind students to add radio waves, X-rays, ultraviolet light, etc. "Why were these left out?" "What are the sources of these waves?"

DEVELOPMENT

1. Ask: "How do we know that some light exists that we cannot see?"

    a. Select several samples of fluorescent minerals. Darken the room and illuminate each of the specimens with a white light source covered with a piece of violet cellophane. Repeat, using an ultraviolet light source.

    A good inexpensive source of violet and ultraviolet light is a mercury lamp with filter, available from many scientific supply houses. Ultraviolet light will fog photographic films or papers.

    CAUTION: Wear glasses to protect your own eyes and make certain that students do not look directly at the source of the ultraviolet light.

    b. Have students compare both sources of light. Identify the invisible rays as ultraviolet rays.

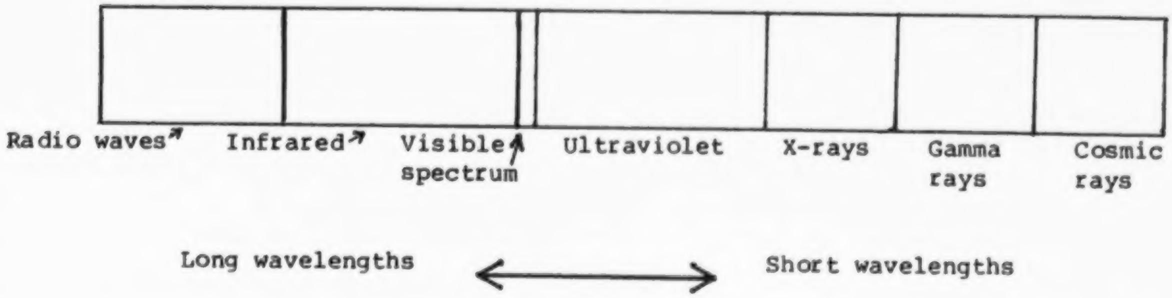
2. Show the class:

    a. infrared and X-ray photographs.
    b. sunburn and heating effects of light.

    Ask: "How are these forms of light different from the light we can see?"

3. Demonstrate the dispersion of sunlight by a prism. Point out that there is invisible light called infrared at one end of the spectrum and ultraviolet light at the other end.

    a. "Why doesn't the prism reveal all these light waves to our eyes?"
    b. "Why are these called light if they cannot be seen?"
    c. Develop concept of electromagnetic spectrum. A diagram such as the one that follows should be developed on the chalkboard:


Radio waves
Infrared
Visible spectrum
Ultraviolet
X-rays
Gamma rays
Cosmic rays
Long wavelengths
Short wavelengths

4. Ask: "How do we use the different forms of light?"

   a. "What is a laser?" The light from a laser has two main properties. It is monochromatic and coherent. The energy in a laser beam depends on the frequency of light, but its brightness depends on the power.

      Explain that lasers have a wide range of uses. Using the laser reflector placed on the moon by astronauts Armstrong and Aldren, scientists are able to measure the distance to the moon within a few centimeters, and are able to locate the exact spot of each moon landing site. Lasers can also be used to amplify heat. Laser heat has been used to drill fine holes in diamonds. The laser is used in medicine to weld a detached retina to the back of the eye. Lasers have also been used in brain surgery and in the treatment of cancer.

   b. Discuss the use of X-rays.

SUMMARY

. "How are our lives affected by light we cannot see?"

FOR FURTHER THOUGHT

. "How do we use laser beams in optical fibers?"

## Lesson 9: HOW DO OUR EYES "SEE"?

AIM: "What parts of the eye enable us to see?"

PERFORMANCE OBJECTIVES: The students will be able to:

- trace the path of a beam of light through the human eye.
- relate the structure of the eye to its function.

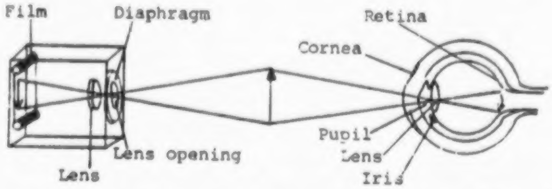
MOTIVATION: Have class close their eyes. Ask: "Why don't you see anything?" Establish that in order for a person to see, there must be light entering the eye.

MATERIALS: Optical bench, screen, model of a human eye.

DEVELOPMENT

1. Identify the four things that are essential for sight:
    a. light
    b. eyes
    c. a nerve to the brain
    d. a vision center in the brain

2. Trace the path of light through the eye by comparing it to the path of light through a camera.



    a. Parts of the eye are transparent, allowing light to pass through.
    b. The transparent parts of the eye (cornea, lens, and the vitreous and aqueous fluids) refract light in the same way as the lenses previously studied.
    c. An inverted image is formed on the retina.
    d. Ask: "How can we see non-inverted images?" (Discuss the role of the optic nerves and vision center in the brain.)
    e. Ask: "How can we see different colors?" (Discuss the roles of the rods and cones.)

SUMMARY

1. "If each eye forms an image, why don't we see double?"

2. "Describe the characteristics of the image that falls on the retina."

FOR FURTHER THOUGHT

1. "The lens of the eye can accommodate both near and far vision. Discuss the characteristics that a lens must have in order to change its focal length."

2. "Why don't we see colors in very dark rooms or at night?"

# Lesson 10: HOW CAN WE MAP THE RETINAS OF OUR EYES?

AIM: "What is our 'blind spot'?"

PERFORMANCE OBJECTIVES: The students will be able to:

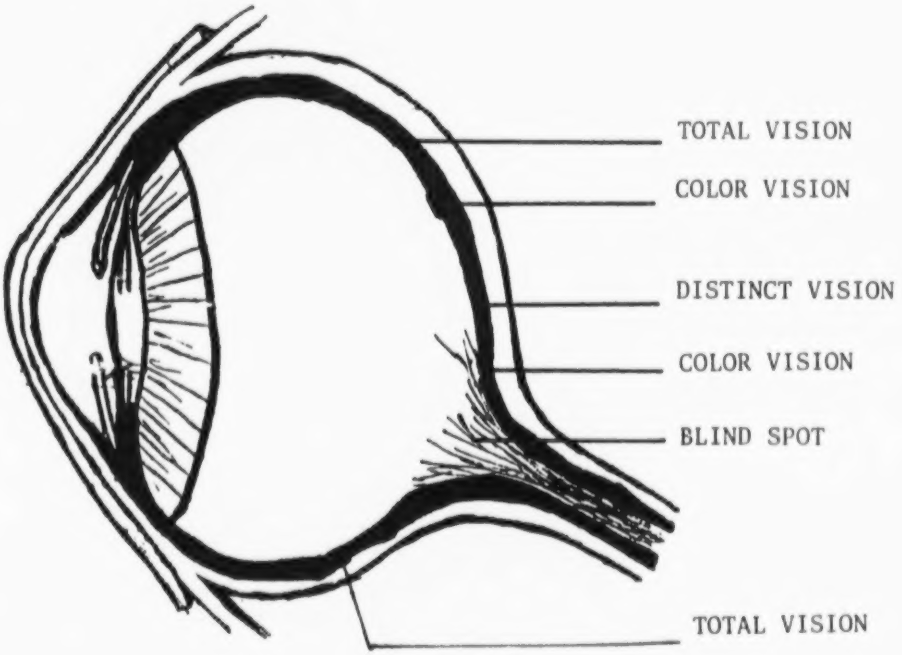
- determine the areas of the retina most sensitive to color, black and white, and distinct vision.

MATERIALS: See Laboratory Worksheet 2.11.

MOTIVATION: "Why do people who view a painting perceive the colors differently?"

DEVELOPMENT

1. Guide students through the procedures on Laboratory Worksheet 2.11.
2. The following is a diagram to guide the teacher:


TOTAL VISION
COLOR VISION
DISTINCT VISION
COLOR VISION
BLIND SPOT
TOTAL VISION

SUMMARY

- See Laboratory Worksheet 2.11.

# LABORATORY WORKSHEET 2.11

NAME______________________ CLASS__________ DATE_____________

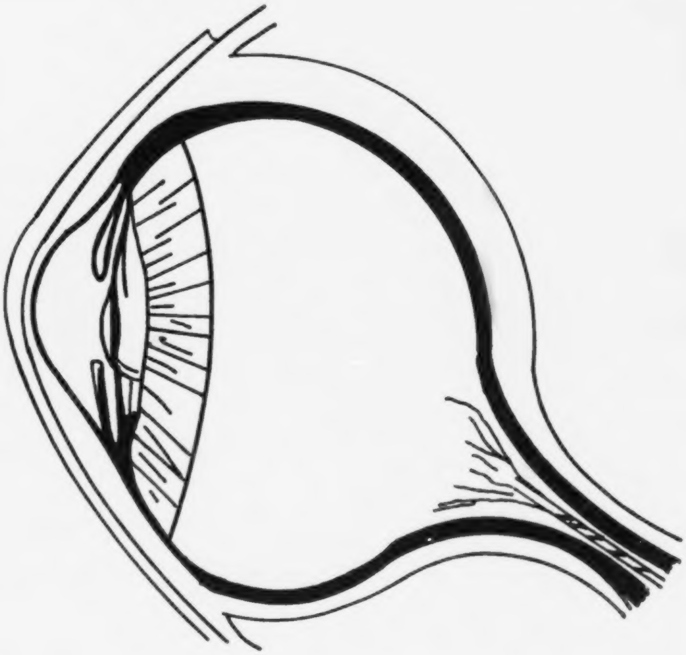
**PROBLEM:** How can we map the retinas of our eyes?

**MATERIALS:** Index card with colored dots.

**INTRODUCTION:** The retina is often called the screen of the eye. It is here that different light rays and colors are detected. It is here that images form. It is here that "nerve fibers" gather the "messages" that transmit our sight to the brain. Today we will study the retinas of our eyes to learn about the sights in our lives.

**PROCEDURE**

1. Identify the areas on the retina where total vision, color vision, and distinct vision are detected. Also identify the blind spot where the ends of the optic nerves are located.



2. Determine the range of your vision:

   a. TOTAL VISION: Close your left eye and stare straight ahead. Now, hold a pen at arm's length and move it to the right until you can no longer see it. Repeat the procedure with your left eye.

   -- What is meant by your range of total vision? ____________________

   ______________________________________________

   -- Let's mark the range of total vision on the retina. (Wait for teacher directions.)

# LABORATORY WORKSHEET 2.11 (continued)

NAME ______________________________

b. DISTINCT VISION: Close your left eye and stare straight ahead. Hold this paper at the outer limits of your visual range. Slowly, move the paper toward you until you can read it clearly. (Use only one eye.)

-- How does your range of distinct vision compare with your range of total vision?

____________________________________________________________

____________________________________________________________

-- Now map the area of distinct vision on the retina. Why must an object be directly in front of you before you can see it clearly?

____________________________________________________________

____________________________________________________________

c. COLOR VISION: Close your left eye. Using the card with colored dots that you have at your table repeat Step 2 of the above procedure.

-- Which color do you recognize first? ____________________

-- Which is the second color that you see clearly? __________

-- Which color comes into view last? ______________________

-- Why do you see the dots in black and white before you recognize them in color?

____________________________________________________________

____________________________________________________________

Let's now map the color area on your retina.

3. Finding the blind spot:

Find the illustration of a rabbit and a hat. Hold the paper about 30 centimeters from your face. Close your right eye. Look at the rabbit with your left eye. Move the paper back and forth until the hat disappears. This is the blind spot of your left eye.

# LABORATORY WORKSHEET 2.11 (continued)

NAME ______________________________

a. On the eye diagram on this Laboratory Worksheet, circle the area of the retina where you think the blind spot occurs. State one reason for your choice.

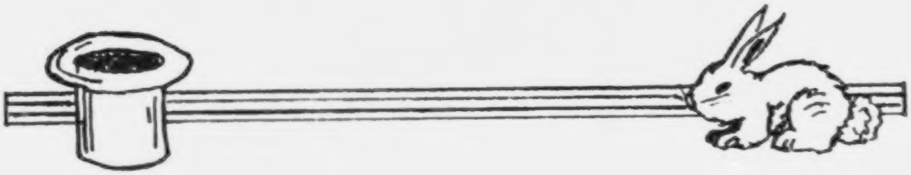
______________________________________________________________________

______________________________________________________________________

b. To find the blind spot of your right eye, repeat the above with your left eye closed. This time, stare at the hat and move the paper until the rabbit disappears.

SUMMARY/HOMEWORK

1. Describe the role(s) of the (a) lens, (b) eye muscles, (c) retina, in producing your sense of vision.
2. Explain why you can see an object best when it is directly in front of your eyes.



# Lesson 11: WHAT ARE SOME COMMON EYE DEFECTS?

AIM: "How does the eye's shape affect our sight?"

PERFORMANCE OBJECTIVES: The students will be able to:

- state the causes of nearsightedness, farsightedness.
- state how eyeglasses correct these conditions.
- confirm that convex lenses correct for farsightedness and concave lenses correct for nearsightedness.

MATERIALS: Eye chart, test for color blindness, overhead projector, film strip projector, moveable screen.

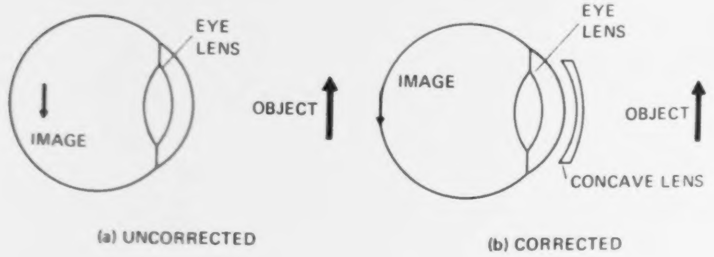
MOTIVATION: Test for color blindness (any textbook contains suitable material).

DEVELOPMENT

1. "What is meant by nearsightedness?"

   a. Draw a diagram of an eye on the board (similar to the one below) or make a transparency of the diagram below.

At the left, you see a condition of nearsightedness. At the right you see how a concave lens in front of a nearsighted eye can bring normal vision to that eye



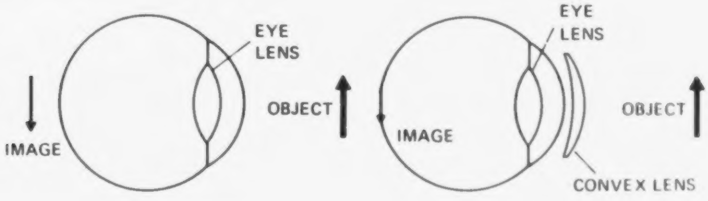
(a) UNCORRECTED (b) CORRECTED

   b. People who cannot see distant objects are said to be nearsighted. The retina is too far from the eye's lens. A concave lens corrects the focus.

2. "What is meant by farsightedness?"

   a. Repeat procedure used in A. (Diagram can be drawn on board or a transparency can be made.)

At the left, you see a condition of far-sightedness. At the right, you see how a convex lens in front of a far-sighted eye can bring normal vision to that eye



(a) UNCORRECTED (b) CORRECTED

   b. People who cannot see nearby objects clearly are said to be farsighted. The retina is too near the lens. The image appears fuzzy because the light hits the retina before it can form a good image. A convex lens helps correct the focus.

3. Illustrate by using a film strip projector and a moveable screen. Move screen (retina) to show how image changes when distances are different.

4. "What is color blindness?"

   a. Both complete and partial color blindness are inborn defects of the cones.
   b. In complete color blindness, all colors are seen as black, shades of grey, or white.
   c. In partial color blindness, red cannot be distinguished from green, and blue cannot be distinguished from yellow.

SUMMARY

1. "How does the shape of the eyeball affect how you see?"

2. "Explain how convex and concave lenses can correct farsightedness and nearsightedness".

## OPTIONAL ACTIVITY

PROBLEM: "How can we correct common eye defects?"

MATERIALS: Overhead projector, screens, shoe boxes, scissors, several pairs of glasses, transparent rulers.

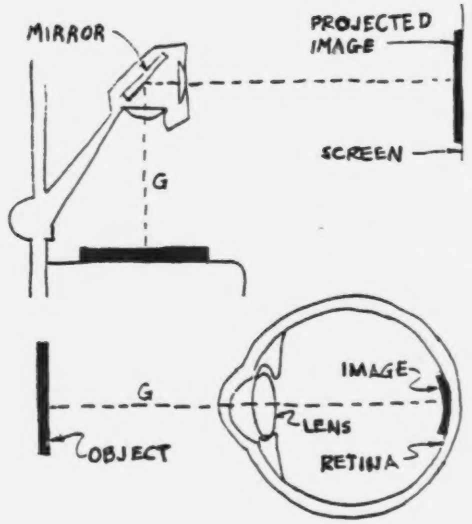
INTRODUCTION: "The optics of an overhead projector are similar to those of the eye in several ways. Study diagram A, which shows how an overhead projector and an eye process light. Compare the eye to the overhead projector. When an object being viewed is in focus, its image will appear clearly on a screen as cast by the overhead projector. The object will also appear clearly on the retina of the eye. The 'G' in the diagram stands for glasses. In this activity you can put eyeglasses on the overhead projector. You can then observe how the lenses change the location of an image."

### PROCEDURE

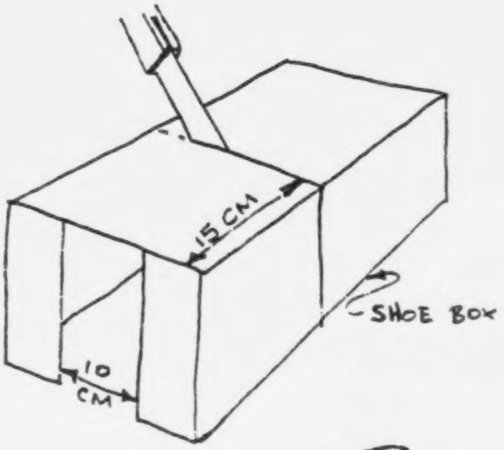
1. Prepare a holder for the eyeglasses by cutting a shoe box (diagram B). Measure 15 cm from one side of the shoe box and cut across the box at this point. Then cut a 10 cm slot across the closed end of the box.
2. Place a transparent ruler on the stage of the overhead projector (diagram C). Turn on the projector. Focus the projector so the numbers on the ruler are in focus on the screen.
3. Place the shoe box holder for eyeglasses on the overhead projector (diagram C).
4. Place the pair of eyeglasses on your holder for testing.
5. Line up one of the lenses between the ruler and the projector lens. The image on the screen should appear fuzzy.
6. Turn the focus adjustment of the projector until the image of the ruler on the screen is in sharp focus.
7. Remove the eyeglasses. The image on the screen should appear fuzzy again.
8. Move the holder forward or backward on the overhead projector stage until the ruler is again in focus. This will tell you if the lens corrected for farsightedness or nearsightedness.
9. Repeat with other pairs of glasses.

### SUMMARY

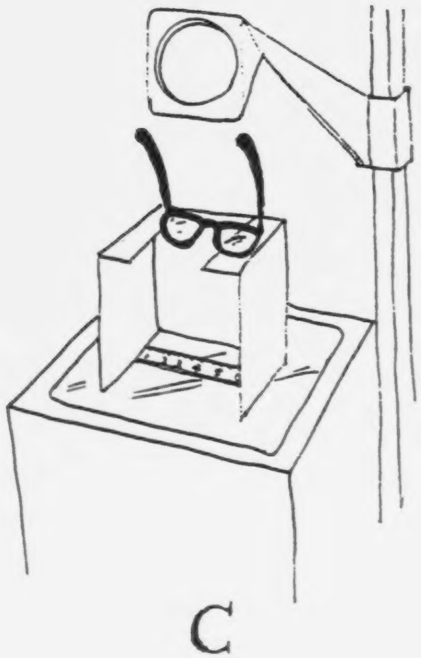
- "Why do people who wear glasses usually take them off when using a microscope?"


MIRROR
PROJECTED IMAGE
SCREEN
G
G
IMAGE
LENS
OBJECT
RETINA

A


15 CM
10 CM
SHOE BOX

B



C

# ADDITIONAL IN-CLASSROOM ACTIVITY

1. "You are watching a live rock show. During the performances the guitarist's clothing seems to change color. At the end of the show, the lights go on and his clothing is white. What could have caused these color changes?"
2. "Why is it more comfortable to wear light colored or white clothes in the summer than dark ones?"
3. "Have you ever seen a rainbow?" "What colors do you see?" "How is a rainbow produced?"
4. Have the students write their names on a sheet of paper. Hold the names up to a mirror and have the class figure the name out by looking at the mirror. "Can you explain what is happening?"
5. "How are shadows used to tell time?"

ESSENTIAL VOCABULARY

1. spectrum
2. prism
3. laser
4. convex
5. optical
6. concave
7. focus
8. reflection
9. image

# Theme II — Questions for Review

Unit 3. I See the Light

NAME______________________ CLASS__________ DATE ______________

1. Sunburn is caused by:
   - a. radio waves
   - b. infrared light
   - c. visible light
   - d. untraviolet light

2. Compared to the object, the size of its image in a plane mirror is:
   - a. larger
   - b. smaller
   - c. the same size
   - d. distorted

3. When a ruler is placed in water at an angle, besides appearing bent, the ruler appears to be:
   - a. curved
   - b. smaller
   - c. magnified
   - d. unaffected

4. An image that can be projected on a screen is called:
   - a. real
   - b. virtual
   - c. projected
   - d. natural

5. A virtual image is seen when we use a:
   - a. microscope
   - b. movie projector
   - c. magnifying glass
   - d. copying camera

6. A reflecting telescope consists of a small plane mirror and a large:
   - a. convex lens
   - b. concave lens
   - c. magnifying glass
   - d. concave mirror

7. Lenses for eyeglasses used by nearsighted people are:
   - a. convex
   - b. converging
   - c. concave
   - d. chromatic

NAME_______________________________________

8. Laser light is:
    a. dangerous to look into
    b. out of step
    c. three shades of one color
    d. made of many wavelengths

9. Your image in a plane mirror is:
    a. magnified
    b. flipped from left to right
    c. smaller than you are
    d. refracted

10. In the eye, images are usually formed on the:
    a. iris
    b. lens
    c. cornea
    d. retina

11. The bending of light is known as:
    a. reflection
    b. refraction
    c. diffraction
    d. dispersion

12. A lens that is thicker in the middle than at the ends is called:
    a. concave
    b. convex
    c. diverging
    d. chromatic

13. An image that can be projected on a screen is called:
    a. real
    b. virtual
    c. achromatic
    d. natural

14. Mirrors affect light by:
    a. changing its speed
    b. refracting it
    c. reflecting it
    d. changing its color

15. Of the colors of light, the color that is refracted most when passing through a prism is:
    a. green
    b. violet
    c. red
    d. yellow

NAME________________________________________

16. The band of visible colors, ranging from red to violet, is called a visual:
    a. rainbow
    b. spectrum
    c. diffraction grating
    d. prism

17. Light:
    a. is a form of energy
    b. travels in straight lines
    c. consists of waves
    d. all of these

18. Invisible electromagnetic waves that have higher energy and shorter wavelengths than violet rays are:
    a. X-rays
    b. ultraviolet rays
    c. gamma rays
    d. all of these

19. A lens that is thicker in the middle than at the edges is called:
    a. convex
    b. concave
    c. plano
    d. reflecting

20. A simple reflecting telescope may be constructed from:
    a. one convex lens
    b. two convex lenses
    c. a convex and a concave lens
    d. none of these

21. The structure in the eyes that helps them change their shape is the:
    a. retina
    b. pupil
    c. eye muscles
    d. aqueous humor

22. Rear view mirrors and anti-shoplifting mirrors:
    a. are convex
    b. allow you to see a large area
    c. produce virtual erect images
    d. all of these

23. Which of the following is not involved in focusing an image in the retina?
    a. muscles
    b. lens
    c. cornea
    d. eye color

NAME________________________________________

24. A person who has difficulty seeing far is:
    a. nearsighted
    b. farsighted
    c. astigmatic
    d. cross-eyed

25. Where is the blind spot on the retina?
    a. It cannot be determined
    b. On the outer edge
    c. It varies with different people
    d. Where the optic nerve exits the eye

True or False

26. _______ A convex lens forms an inverted, smaller, real image when it is far away from the object.

27. _______ An image that can be focused on a screen is a real image.

28. _______ An image in a plane mirror appears to be behind the mirror.

29. _______ A convex lens causes parallel light rays to converge (come together).

30. _______ The bending of light as it passes from one kind of transparent material to another is called reflection.

Explain the Following

31. How is the human eye like a camera?

32. How can you determine whether an image is real or virtual?

33. Describe some uses of lasers.

34. Explain how a prism disperses a beam of white light into different colors.

35. Compare the image of an object in a plane mirror with the object itself with respect to each of the following:
    a. size
    b. distance from mirror
    c. color

NAME_______________________________________

Multiple Choice

36. An opaque object completely blocks light. If a light is directed at an opaque object:
    a. light is reflected
    b. light bounces off the object
    c. a shadow forms
    d. all of the above

37. Mr. Segal had three pieces of cardboard 4 inches X 4 inches. Each had a tiny pinhole in the center. Mr. Segal placed the pieces of cardboard 3 feet apart and upright on a table. He could look through the the pinhole in the first piece of cardboard and see a candle's flame which was behind the last cardboard square. This demonstration helps to show that light:
    a. will bend
    b. is energy
    c. will travel in a straight line
    d. is really photons of varying wavelengths

38. Andrew had a radiometer which he placed in sunlight. The radiometer's vanes turned. This demonstrates that light is:
    a. energy
    b. waves
    c. necessary to produce electricity
    d. bent or refracted when it passes through glass

39. A coin was placed in a cup. Scott couldn't see the coin from his seat. Larry added some water to the basin. Scott did not move, but he could now see the coin because:
    a. water magnified the coin's image
    b. light was bent or refracted by the water, so the coin became visible
    c. light was reflected by the water
    d. the coin floated toward the surface of the water

40. A watch or glass lens could be used to start a fire because it can:
    a. distribute the sun's rays equally over a large area
    b. make light rays diverge or spread apart
    c. make the sun's rays converge or come close together
    d. reflect the light

NAME________________________________

41. A crystal chandelier had many small, clear, colorless glass crystals. Yet when the lights are turned on, the crystals seem to contain a rainbow of colors. This is because:
    a. white light was separated into a spectrum of colors by the glass crystals
    b. glass always produces colors from white light
    c. light consists of thousands of types of photons or energy bundles
    d. the speed of light increased when it passed through the crystals

42. The color that is refracted the most by a prism is:
    a. red
    b. violet
    c. green
    d. orange

43. One reason a rainbow forms is that:
    a. water is more dense than air
    b. light travels in a straight line through a water droplet
    c. light travels at a constant speed through all media
    d. water consists of different colored molecules

44. Mitch saw his image in a small plane mirror. The size of the image was:
    a. smaller than Mitch
    b. larger than Mitch
    c. the same size as Mitch
    d. one-half the size of Mitch

# UNIT 4. A SOUND REASON

## Lesson 1: WHAT CAUSES SOUND?

AIM: "Why can't we hear the bell?"

PERFORMANCE OBJECTIVES: The students will be able to:

- explain that sound is produced when matter vibrates.
- apply the Kinetic Molecular Theory to production of sound.
- identify a definite problem for a specific situation.
- reason abductively (hypothesis formation), inductively, and deductively.

MATERIALS: Battery jar, bell, vacuum pump, wire, switch, ruler, clamp, string, pith ball or ping-pong ball, tuning fork, ring stand and clamp.

MOTIVATION: Display a bell inside a large battery jar to which a vacuum pump is attached. Allow the bell to ring. Turn on the vacuum pump and slowly evacuate the air in the battery jar. Have the students listen and observe.

DEVELOPMENT

1. Have the students describe what they observed.
   a. Elicit there was a bell in a battery jar. When the bell was turned on, it was easily heard.
   b. Then the vacuum pump was turned on. Ask: "How did turning on the vacuum pump affect what you heard?" Elicit the sound faded until it was no longer heard. Emphasize the fact that the bell was still operating, but the sound could NOT be heard.
2. Have the students explain what occurred.
   a. Ask: "How did turning on the vacuum pump affect the battery jar and its contents?" (The vacuum pump removes the air from the battery jar leaving a vacuum around the bell.)
   b. Ask: "How did removing the air from the battery jar affect the sound?" (The sound faded until it no longer could be heard.)
   c. Ask: "What do you conclude?" (Sound is transmitted, or carried, by the air in the battery jar. Sound will not travel in a vacuum.)
   d. Ask: "What is necessary for sound to travel?" (Sound requires a medium in which to travel. The medium may be a solid, a liquid or a gas.)
3. Apply the Kinetic Molecular Theory to the demonstration.
   a. Ask: "Of what is matter composed?" (According to the Kinetic Molecular Theory, all matter is composed of atoms or molecules.)
   b. Ask: "How does the bell affect the air molecules in the battery jar?" (The vibrating bell forces the air molecules in the battery jar to vibrate. The battery jar vibrates, causing the air in the room to vibrate. The air molecules in the room collide with other air molecules in the room. This carries the sound to our ears.)

   c. Explain that vibrating molecules transfer energy to other molecules. The transfer of energy from molecule to molecule is a type of wave that carries sound. A given molecule in the medium will remain in the same place after transmitting its energy.

4. Have the students observe the following demonstrations:

   a. Vibrate a ruler with one end overhanging a desk and the other end clamped to the desk.
   b. Touch a vibrating tuning fork against a suspended pith ball or ping-pong ball.
   c. Partially immerse the tines of a vibrating tuning fork into a large battery jar filled with water.

5. Have the students explain how each demonstration produced sound.

   a. Ask: "How did vibrating the ruler, the tuning fork, and the pith ball affect the air?"
   b. Ask: "How did the immersion of the vibrating tuning fork affect the water molecules?"
   c. Ask: "How did the water molecules affect the air molecules?"

SUMMARY

1. "How would putting air back into the evacuated battery jar affect what you hear?"

2. "What is necessary to produce and transmit a sound?"

3. "How does the Kinetic Molecular Theory help to explain the transmission of sound?"

4. "Why may an air molecule be in the same place it was before and after it helped to transmit sound?"

5. "Explain how a vibrating ruler, pith ball, or tuning fork produce sound."

# Lesson 2: HOW DO SUBSTANCES DIFFER IN THEIR ABILITY TO TRANSMIT SOUND?

AIM: "How can we discover which material is the best sound transmitter?"

MATERIALS: See Laboratory Worksheet 2.12.

PERFORMANCE OBJECTIVES: The students will be able to:

- explain that dense, rigid materials transmit sounds better than less dense, soft materials.
- design a method or experiment to test the ability of materials to transmit sounds.
- identify variables in an experimental design.
- manipulate specific laboratory equipment.
- comprehend the need for controls in experiments.

DEVELOPMENT:

1. Distribute Laboratory Worksheet 2.12 and guide the students through the procedures.

2. Ask: "What can we find out by striking the tuning fork and holding its end against each material?"

3. Ask: "What are some variables or factors that may cause us to draw incorrect conclusions?" (There are many variables, the force of striking the tuning fork, the time between striking the tuning fork and holding it against the object, and the "measuring" of the sound are just a few variables.)

4. Have the students perform the laboratory activities.

# LABORATORY WORKSHEET 2.12

NAME:________________________________ CLASS_________ DATE________________

PROBLEM: How can we discover which material is the best sound transmitter?

MATERIALS: Tuning fork, rubber stopper, wooden dowel, plastic ruler, sponge, board eraser, glass rod, metal rod (tripod leg), string, 2 tin cans or paper cups with holes punched in the closed ends.

PROCEDURE

1. Develop with your teacher and class, and then with your laboratory group, a method for testing and comparing the ability of materials to transmit sound.

2. Perform the activities and complete the following table. What type of rating scale will you use?

| MATERIAL | ABILITY TO TRANSMIT SOUND |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

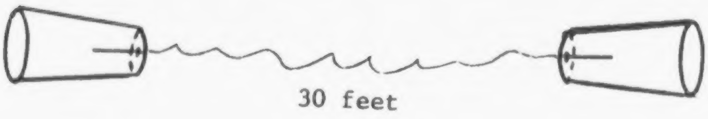
a. What were some variables or possible sources of errors in your experiment? Explain.
b. How might such variables be eliminated or CONTROLLED?

# LABORATORY WORKSHEET 2.12 (continued)

NAME ______________________________

3. Obtain 2 paper cups or tin cans. Punch a small hole in the center of the bottom of each.

   a. Using about 30 feet of string, thread the ends through the holes and knot them.



   b. Stretch the string tightly and do not allow it to touch anything.
   c. Without using your cup, whisper to your friend who is holding the other end of the thirty-foot string. Can your friend hear you?
   d. Now, whisper into your cup while your friend places his/her cup to his/her ear. Why is it easier for your friend to hear you?

SUMMARY/HOMEWORK

1. Based upon your laboratory activities, what do you conclude?
2. Briefly discuss some experimental variables in your procedures.
3. How does the Kinetic Molecular Theory help to explain your results?
4. How did using the cup affect your friend's ability to hear you? Explain.
5. Compare the speeds of sound in different solids, liquids, and gases.

## Lesson 3: HOW DOES SOUND TRAVEL FROM ONE PLACE TO ANOTHER?

AIM: "How does the air carry sound from a tuning fork to your ear?"

PERFORMANCE OBJECTIVES: The students will be able to:

- analyze the motion of a tuning fork.
- explain how sound travels by means of longitudinal waves.
- distinguish between compression and rarefaction.
- apply previous learning to new situations.
- reason inductively and deductively.

MATERIALS: Spring with large diameter or Slinky, tuning fork.

MOTIVATION: Place a coiled spring with a large diameter or a Slinky on the floor or on the demonstration table. Stretch the spring or Slinky. Have the students observe and pull several coils of the strectched spring or Slinky together, and then release the coils to create a disturbance or pulse.

DEVELOPMENT

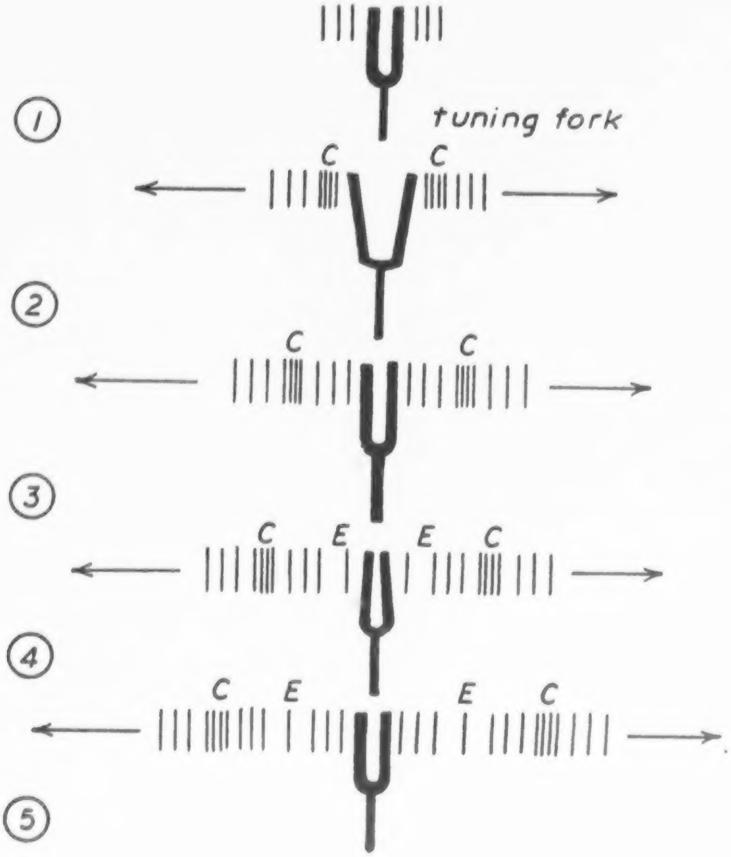
1. Have the students describe what they observed. Elicit that a disturbance or pulse was created. The energy of the disturbance moved along the length of the spring. The disturbance in the spring caused coils farther along the spring to be compressed. Each compressed section was followed by an expansion of the spring.

2. Lead the students to explain how striking a tuning fork affects the air. Strike a tuning fork, and have students describe what they hear. Ask: "How does the tuning fork's prong affect surrounding air molecules?" (Since air is elastic, as each prong moves toward the listener, the surrounding air molecules are crowded together. This is a compression. As the prongs move back, the crowded or compressed air molecules move apart. This is a rarefaction. Alternate compressions and rarefactions constitute a SOUND WAVE, which travels outward in all directions.)

3. Students should be able to relate the transmission of the pulse along the spring, and the movement of air molecules caused by the tuning fork.
   a. Explain that compressions and rarefactions constitute a sound wave. A sound wave is a wave in which the vibrating molecules move parallel to the path of the wave. This type of wave is called a LONGITUDINAL WAVE.
   b. A wave is a disturbance in a medium. Ask: "In the case of the pulse in the spring, what provided the energy for the disturbance?" Ask: "What is the medium that transmitted the pulse?" Ask: "Why can't sound waves travel above the surface of the moon?" (No medium.)

# DIAGRAM OF TUNING FORK VIBRATIONS

Ask, "How does sound travel through a medium?"
Suggest that an answer might be found, using the knowledge of how a tuning fork vibrates. The following diagram is needed:


①
tuning fork
C
C
②
C
C
③
C
E
E
C
④
C
E
E
C
⑤

SUMMARY

1. "How does pulling several coils of a stretched spring or Slinky together and then releasing the coils affect the spring?"
2. "How is the movement of a spring similar to sound waves in the air?"
3. "How does a vibrating tuning fork affect the air?"
4. "What would happen if you struck a tuning fork on the moon? Explain."
5. "How do compressions and rarefactions differ?"
6. "What is a longitudinal wave?"
7. "How does sound travel from one place to another?"

# Lesson 4: WHAT ARE THE CHARACTERISTICS OF SOUND WAVES?

AIM: "How can we make a tuning fork produce a louder sound?"

PERFORMANCE OBJECTIVES: The students will be able to:

- comprehend the meaning of wavelength, frequency, and amplitude with respect to sound waves.
- analyze characteristics of a sound wave.
- apply previous learnings to new situations.
- reason inductivley and deductively.

MATERIALS: High-pitched whistle, long (20 ft.) rope, tuning fork.

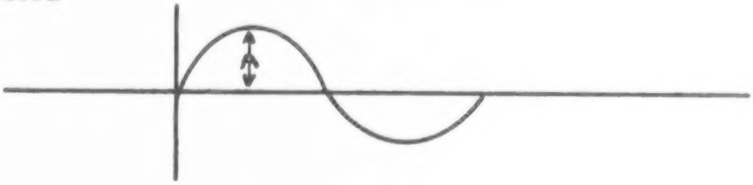
MOTIVATION: Have a student clap hands gently so that the sound produced is inaudible. Instruct the student to increase the force gradually. Ask the other students to raise their hands when they can hear the clapping. Bring in a dog whistle which is inaudible to humans. Blow the whistle and have students describe what they see and hear.

DEVELOPMENT

1. Ask: "How does clapping harder affect sound?" (The sound gets louder.)
    a. Strike a tuning fork gently and then vigorously. Guide the students to conclude that a sound's loudness or intensity depends upon the amount of energy used to produce it.
    b. Explain that intensity varies with the amount of sound energy received per unit of time. The unit of intensity is the decibel. A soft whisper is about 10 - 15 decibels, while a thunder clap may be greater than 100 decibels.

2. Have the students observe waves on a long piece of rope with a bell hanging from the distant end. Ask: "How does the wave motion affect the sound intensity?" (The greater the energy used to move the rope, the greater the movement of a rope segment from its rest position.)
    a. Tell the students that the amplitude of a wave is the measure of the maximum movement of the wave from its normal rest position. Draw a wave form on the board and label its Amplitude.

AMPLITUDE

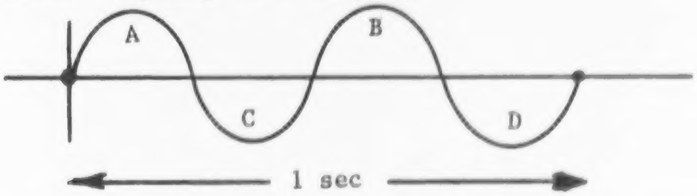


    b. Ask: "How would the amplitude of a loud sound wave compare to the amplitude of a soft sound wave?"

3. Ask a student to sing a high pitch note and then a low pitch note of the same loudness and duration. Ask: "How do the sounds differ?" Elicit the fact that the sounds are of a different pitch. Differences of frequency are heard as differences of pitch, which is a measure of the response of our ears to different tones.

   a. Define frequency as the rate at which vibrations are produced per unit of time. Five (5) complete waves in one second is a frequency of 5 waves per second.
   b. Ask: "How many compressions and how many rarefactions are there in a wave with a frequency of 5 cycles per second?" (There are 5 compressions and 5 rarefactions.)
   c. Explain that humans can only detect frequencies of from 20 to 20,000 cycles per second. Return to the dog whistle. Ask: "Why can a dog hear the sound of the whistle?"

   Illustrate frequency in a diagram:



   Ask: "What is the frequency illustrated in this diagram?" (It is 2 cycles/sec.)

4. Ask: "What is wavelength?" Define wavelength as the distance between two successive compressions or rarefactions. On the diagram, the distance from A to B or from C to D is a wavelength.

SUMMARY

1. "How does clapping your hands with increased force affect sound?"

2. "How is sound's intensity affected by the rate of clapping your hands together?"

3. "What is measured in units of decibels?"

4. "How do molecular motions in the medium vary with sound intensity?"

5. "What is meant by a wave's amplitude?"

6. "Draw a wave and show its amplitude."

7. "Compare the amplitude of a loud sound with the amplitude of a soft sound."

8. "Compare the frequency of the sound produced by a high pitched-soprano with the sounds produced by a deep-voiced bass."

9. "Why can't we hear the sound produced by a dog whistle?"

10. "How does frequency differ from wavelength?"

# Lesson 5: HOW DOES THE HUMAN EAR DETECT SOUND?

**AIM:** "How do we hear the air that is set into motion by a tuning fork?"

**PERFORMANCE OBJECTIVES:** The students will be able to:

- explain how the human ear detects sound.
- explain how sound is transmitted to the brain.
- apply the Kinetic Molecular Theory to a specific situation.
- reason inductively and deductively.

**MATERIALS:** 1000 ml. beaker, rubber sheet, chart or diagram of the human ear, tuning fork.

**MOTIVATION:** Stretch a sheet of rubber tightly across a beaker's open end. Have a student speak directly into the rubber sheet. Have another student touch the rubber lightly and describe the sensation that is felt.

**DEVELOPMENT**

1. Ask: "How did speaking directly into the rubber sheet affect the rubber sheet?" (The rubber sheet started to vibrate.)
    a. Ask: "How did the sound from your vibrating vocal cords get to the rubber sheet?" (The vibrating vocal cords caused air molecules in the throat to vibrate. Air molecules in front of the lips carried sound waves to the rubber sheet, which was set into vibration at the same frequency.)
    b. Have the students explain how the transmission of sound from the human voice to the rubber sheeting is related to the Kinetic Molecular Theory. (Same explanation as stated previously.)

2. Strike a tuning fork. Ask: "How do we hear the vibrationg air?"
    a. Trace the sound waves from the tuning fork to the ear. Display a chart or transparency of the human ear. Identify the outer ear, middle ear, and inner ear. Ask: "How do sound waves get to the ear's canal?" (Sound waves are picked up by the large outer ear and led into the canal.)
    b. At the end of the canal, the sound waves hit the eardrum, which is stretched across the opening of the middle ear. Ask: "How does the sound wave affect the eardrum?" (The sound waves cause the eardrum to vibrate. Emphasize the fact that the eardrum is a membrane that separates the outer ear from the middle ear.)
    c. Point out that sound vibrations are reinforced or amplified by three small bones in the middle ear, popularly called the hammer, anvil, and stirrup. The vibrations there enter the middle ear and are transferred to a fluid in the cochlea. Have the students identify the snail-shaped cochlea.
    d. The fluid in the cochlea starts to vibrate, and the vibrations stimulate the auditory nerves, which carry the sensations to the brain. The brain interprets these vibrations as sound waves.

## SUMMARY

1. "Describe the transmission of sound from the human vocal cords to the auditory nerves of the ear."
2. "How is a vibrating rubber sheet analogous to the human eardrum?"
3. "Describe the human ear's structure."
4. "How does the Kinetic Molecular Theory help to explain how human's hear?"

# Theme II — Questions for Review

## Unit 4. A Sound Reason

NAME____________________________ CLASS _______________ DATE___________________

1. An astronaut struck a tuning fork on the moon. No sound was heard because:
   a. the tuning fork did not vibrate
   b. not enough energy was provided to produce sound
   c. the moon has no atmosphere, so there was no medium to carry the sound
   d. the sound waves were absorbed by the moon's craters

2. A vibrating bell was in a bell jar which had no air. As air was pumped INTO the jar:
   a. the sound of the bell increased
   b. the sound of the bell disappeared
   c. fewer sound waves were produced
   d. a vacuum was being produced inside the battery jar

3. Sound will not travel in a:
   a. solid
   b. liquid
   c. gas
   d. air
   e. vacuum

4. Sarah clapped her hands and produced a sound. By clapping, Sarah:
   a. provided forces which made air molecules vibrate
   b. created a total vacuum, which is needed for sound transmission
   c. expanded the size of air molecules
   d. forced the molecules of his hands to vibrate, but prevented air molecules from vibrating

5. Sound can be carried by:
   a. air
   b. iron
   c. water
   d. all of the above

6. To produce sound, it is necessary to have:
   a. a vacuum
   b. air
   c. energy
   d. specific chemicals

7. Pam touched the base of a vibrating tuning fork to blocks of iron, lead, sponge, and cardboard. The best amplifier of sound was the:
   a. iron
   b. sponge
   c. cardboard
   d. lead

NAME ______________________________

8. Sound is transmitted best by:
   a. dense, rigid materials
   b. dense, soft materials
   c. less dense materials
   d. air

9. Anita discovered that the substance her teacher said was the best transmitter of sound was not correct according to Anita's experimental results. A plausible explanation is:
   a. Anita might not have struck the tuning fork with equal force when she tested each block
   b. the teacher could have been wrong
   c. Anita might have miscalculated the loudness of the different sounds she heard
   d. all of the above

10. Sam connected the bottoms of two paper cups with a long string. His friend Pam was able to hear him whispering into one cup while she listened with the second cup at the end of the taunt string because:
    a. air molecules in the cup vibrated when he spoke
    b. the string was stretched
    c. the string vibrated
    d. all of the above

11. Sam's cup and string "walkie-talkie" helps to show:
    a. air is a better sound transmitter than string
    b. string can be a better sound transmitter than air
    c. how an electric telephone carries sound waves
    d. air cannot be used to transmit sound

12. David banged two rocks together when William was 40 feet away. It would have been easier for William to hear the sound if David hit the rocks in the:
    a. air, and William's ears were in the air
    b. air, and William's ears were underwater
    c. water, and William's ears were underwater
    d. water, and William's ears were in the air

13. Mr. Wisoteky placed a Slinky on the floor and stretched it. At various points he held a few sections together and then released them. This produced a:
    a. sound wave
    b. pulse or disturbance
    c. lateral wave
    d. broken Slinky

14. Striking a tuning fork:
    a. creates a sound wave in a vacuum
    b. produces compressions in surrounding air molecules
    c. will usually break the fork
    d. releases fluid in our ears

NAME ______________________________

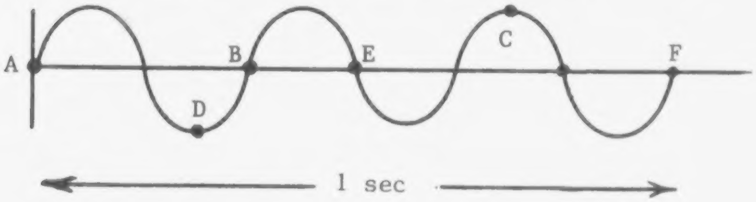
15. Humans cannot hear a dog whistle because the:
    a. amplitude of the sound wave produced is too small
    b. frequency is too great
    c. frequency is less than 15 vibrations per second
    d. volume is too low

16. Melanie struck a tuning fork and waited until it stopped vibrating. She struck it a second time, but with more force. The second time, the tuning fork had:
    a. a frequency that was less than the first time it was struck
    b. an intensity that was the same as the first time it was struck
    c. an intensity that was greater than the first time it was struck
    d. almost twice the frequency as the first time

17. As a sound wave's intensity increases, the molecular motion the sound wave produces:
    a. increases
    b. decreases
    c. remains the same
    d. increases in proportion to the distance the molecules are from the source of the sound

18. Differences in frequency produce different:
    a. intensities
    b. volumes
    c. pitches
    d. amplitudes

19. The indicated frequency of the following wave form is:



    a. 1 cycle per second
    b. 3 cycles per second
    c. 6 cycles per second
    d. 3 cycles per 1/2 second

20. A wavelength for the above wave is the distance from:
    a. A to B
    b. D to B
    c. A to D
    d. A to C
    e. D to F

NAME ______________________________

21. Mr. Doc had a rubber sheet stretched across a beaker's open end. He spoke into the rubber sheet. This caused:
    a. the beaker to break
    b. sound waves of greater frequency
    c. the rubber sheet to contract
    d. the rubber sheet to vibrate

22. Traci struck a tuning fork. Kim heard the sound because the tuning fork:
    a. vibrated
    b. disturbed air molecules
    c. air molecules disturbed Kim's eardrum
    d. all of these

23. The rubber sheet that Mr. Doc stretched across the beaker is similar to the:
    a. outer ear
    b. middle ear
    c. inner ear
    d. ear drum

24. The middle ear is separated from the outer ear by the:
    a. ear drum
    b. bones
    c. anvil
    d. hammer

25. Sound vibrations are amplified or reinforced by the:
    a. ear drum
    b. outer ear
    c. three small bones in the middle ear
    d. all of the above

# UNIT 5. A "CURRENT" TOPIC

***NOTE TO TEACHER:** The topic of electricity is taught in the present seventh grade science curriculum. The areas that should have been covered in the seventh grade are:

1. What is meant by an electric current?
2. What is a series circuit?
3. What is a parallel circuit?
4. Wire resistance.
5. How the resistance of a wire can be changed.
6. How is electric current measured?
7. How is electromotive force measured?
8. Ohms Law.

In order to help you determine whether the topic of electricity should be retaught to your students, a pretest is included. Based on the results of the pretest, you may find it necessary to teach only the material in lessons 1, 2 and 5 of this ninth grade curriculum.

# Pretest

## Unit 5 - Electricity

NAME ______________________ CLASS __________ DATE ____________

1. An electric current is a flow of electrons from:
   a. negative to positive
   b. positive to negative
   c. negative to negative
   d. positive to positive

2. In a series circuit the electrons have:
   a. many paths to follow
   b. two paths to follow
   c. one path to follow
   d. high velocity

3. Parallel circuits:
   a. permit independent operation of electrical devices
   b. draw less current from the source
   c. are used only with lamps
   d. cannot work with batteries

4. In normal house wiring, electrical outlets are connected in:
   a. parallel circuits
   b. series circuits
   c. short circuits
   d. long circuits

5. A substance through which electrons will not flow easily is called a(n):
   a. conductor
   b. insulator
   c. metal
   d. magnet

6. Which of the following will not affect the resistance of a wire?
   a. the length
   b. the thickness
   c. the nature of the metal
   d. the insulation

7. A voltmeter:
   a. is more easily damaged than an ammeter
   b. does not have much resistance
   c. is connected in series with the rest of the circuit
   d. is connected in parallel with the rest of the circuit

NAME ______________________________

Matching

| | Column A | | Column B |
|---|---|---|---|
| 8. | Measures EMF | a. | Parallel circuit |
| 9. | Measures electric current | b. | Ammeter |
| 10. | Reverses itself | c. | AC |
| 11. | One path for electrons to follow | d. | Dry cell |
| 12. | Several paths for electrons to follow | e. | Step-Up Transformer |
| 13. | Increases voltage | f. | Voltmeter |
| 14. | Opens and closes electrical circuits | g. | Switch |
| 15. | Source of emf | h. | Series circuit |

## Lesson 1: WHAT IS STATIC ELECTRICITY?

AIM: "Why does the balloon cling to the wall?"

PERFORMANCE OBJECTIVES: The students will be able to:

- discover that objects can be electrically charged.
- demonstrate that electrons can do work.
- illustrate the behavior of electrically charged bodies.
- apply previous learnings to a new situation.

MATERIALS: Laboratory Worksheet 2.13, copper wire 50 cm long, two strips of aluminum foil 3 cm x 1 cm, Erlenmeyer flask, one-hole stopper, plastic or rubber comb, piece of paper, lucite or plexiglass rod, piece of silk.

MOTIVATION: "Why can walking across a carpeted room be a shocking experience?" "Why does a balloon cling to a wall after it has been rubbed against a person's hair?"

DEVELOPMENT

1. Distribute Worksheet 2.13.
2. Have students offer possible explanations of the phenomenon described in the Motivation.
3. Develop the concept that static electricity is used to describe an electric charge not in motion.
4. Review the concept that static electricity is an excess of electrons, resulting in a negative charge or a deficiency of electrons resulting in a positive charge.
5. Have the students explain why silk imparts a positive charge to the lucite or plexiglass rod.
6. Ask: "What would happen if a comb were touched to the copper wire in the electroscope?" (See Laboratory Worksheet 2.13; the comb will furnish electrons [from hair] to the copper wire and thus charge the aluminum leaves negatively. These like charges will cause repulsion and movement. Discharge back to the neutral state is produced when the copper wire is grounded.)

SUMMARY

- See Worksheet 2.13.

FOR FURTHER THOUGHT

1. "Make a list of some practical uses for static electricity."
2. "How did Ben Franklin, in 1752, show that static electricity can be put to work?"

# LABORATORY WORKSHEET 2.13

NAME ______________________ CLASS ______________ DATE ____________

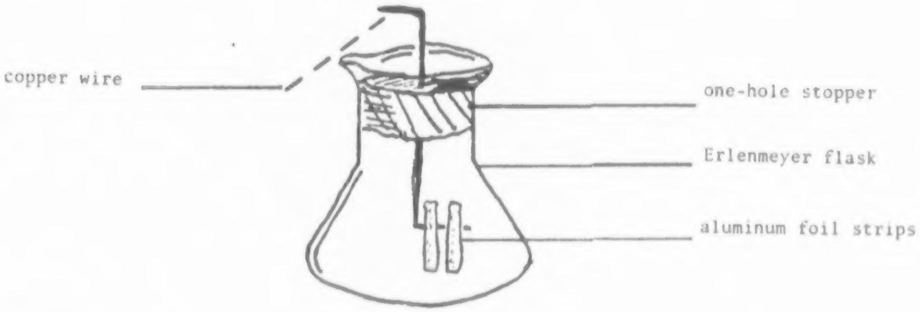
PROBLEM: What is static electricity?

MATERIALS: Copper wire, two strips of aluminum foil, Erlenmeyer flask, one-hole stopper, comb, pieces of paper, glass rod, piece of silk.

INTRODUCTION: Why do you sometimes get a shock when you touch a metal object after walking across a carpeted room? Why do clothes sometimes cling together when removed from a clothes dryer? Today we will become acquainted with the behavior of the charged particles that are responsible for these phenomena.

PROCEDURE

1. Insert the copper wire through the stopper. Bend both ends at right angles to the rod. Hang the two leaves of aluminum foil at one end. Insert the cork in the Erlenmeyer flask. This setup is called an electroscope. Check your setup against the diagram below:



Touch a comb to the exposed end of the copper wire. Why don't the aluminum leaves react to the comb?

2. Comb your hair about 20 times. Then touch the copper wire with the comb.

How does this affect the positions of the aluminum leaves?

# LABORATORY WORKSHEET 2.13 (continued)

NAME ______________________________

3. Touch the copper wire with your finger.

   a. How do we know that the aluminum leaves were uncharged (neutral) at the start of the experiment?

   ______________________________

   ______________________________

   b. What was the effect on the aluminum foil of the electrons that were removed from your hair by the comb?

   ______________________________

   ______________________________

   c. Why did the aluminum leaves come together when you touched the copper wire with your finger?

   ______________________________

   ______________________________

   d. Predict what will happen if you bring the comb near your hair after you comb it.

   ______________________________

   ______________________________

   Test your prediction.

4. Tear a sheet of paper into small pieces. Comb your hair and bring the comb close to the pieces of paper.

   Record your observations.

   ______________________________

   ______________________________

5. Rub a lucite or plexiglass rod with a piece of silk to build up a charge. Use some pieces of paper to see if this produces a similar action as the charged comb near the electroscope. What happens?

   ______________________________

   ______________________________

# LABORATORY WORKSHEET 2.13 (continued)

NAME ______________________________

SUMMARY/HOMEWORK

1. How can you protect yourself from a shock after walking across a carpet?
2. How did you show that electrons can produce work?
3. What is meant by "static cling"?
4. Why must computers be protected against static electricity?

FOR FURTHER THOUGHT

- Why is an uncharged object attracted to a charged rod initially, but repelled by it after contact is made with the rod?

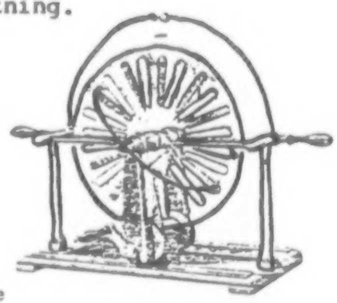
## Lesson 2: WHAT IS ATMOSPHERIC ELECTRICITY?

AIM: "How does a Wimshurst machine produce a spark?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe how lightning is formed.
- discuss both the beneficial and harmful effects of lightning.
- describe how we can protect ourselves from lightning.

MATERIALS: Wimshurst machine.

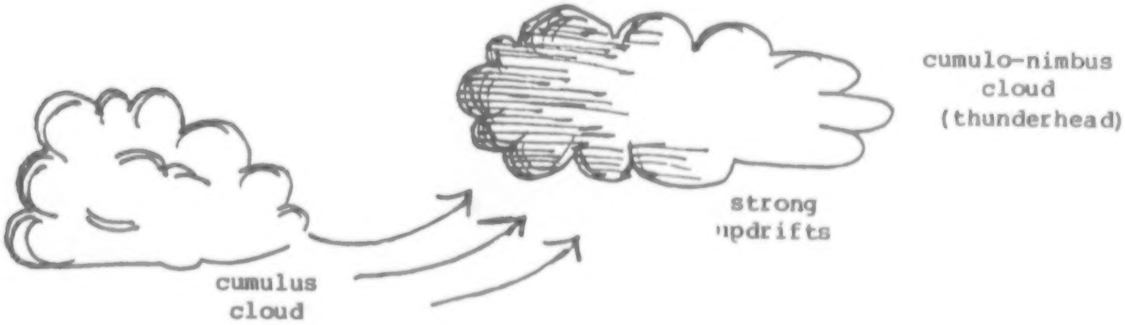


Wimshurst machine

MOTIVATION: Have students assist you with Wimshurst machine. Ask: "How is the spark produced?"

DEVELOPMENT

1. Ask: "What causes lightning?" One possible explantion is as follows:



The rising air currents cause friction between molecules (static electricity). Large electrical charges are built up. When these charges are transferred to the ground, we have lightning. (The rapid expansion of the superheated air produces thunder.) Another explanation is that lightning is caused by the separation of charges as water droplets are carried up through the cloud. This latter explanation is generally considered most likely to be correct.

2. Ask: "What are the beneficial results of lightning?" Lightning supplies the energy for the chemical combination of nitrogen and oxygen, which results in the formation of nitrogen oxide. When the nitrogen oxides combine with water, they form nitrous acid and nitric acid, which fall to earth in raindrops and snowflakes. The acids react with chemicals in the soil, forming nitrites and nitrates. The nitrates act as fertilizer.

3. Ask: Why is lightning dangerous?" Discuss dangers of lightning.

SUMMARY

1. "Why should swimmers at Coney Island leave the water during a thunderstorm?"

2. "Why are people in closed automobiles better protected from lightning during a thunderstorm than people under trees?"

FOR FURTHER THOUGHT

1. "Why should an outdoor TV antenna always be grounded?"

2. "There is an old saying, 'Lightning never strikes twice in the same place.' Explain why this is not correct." "The Empire State Building is often struck by lightning more than once during a storm. "Why not the surrounding buildings?"

3. Ask: "Why is lightning dangerous?" Lightning can start fires, electric power lines can be damaged, lightning can electrocute you, and it can destroy property.

   Buildings may be protected from lightning by lightning rods. The charge built up in the air by a storm is slowly and quietly discharged by the lightning rods. If a cloud has a negative charge, the lightning rod will drain extra electrons from the air to the ground. If the cloud charge is positive, the earth supplies the electrons needed to help neutralize the cloud. The lightning rod acts as a good conductor, which carries the charge safely into the ground. A lightning rod must be grounded.

4. "How do lightning rods protect a building?"

## Lesson 3: WHAT IS MEANT BY AN ELECTRIC CURRENT?

[OPTIONAL]

AIM: "How can we make the bulb light?"

PERFORMANCE OBJECTIVES: The students will be able to:

- identify electricity as an energy source.
- describe characteristics associated with electrons flowing in a circuit.

MATERIALS: 1.5 V dry cell, copper wire, 1.5 V flashlight bulb in socket.

MOTIVATION: Display the dry cell, wire, and the bulb. Ask: "How can we make the bulb light?" Elicit that the components must be connected in a circuit.

DEVELOPMENT

1. Identify and demonstrate a simple circuit.
    a. Ask: "How does this demonstration show that electricity is a form of energy?"
    b. Ask: "Where did the energy to light the bulb come from?"
    c. Define current electricity as electrons moving from one place to another.
2. Ask: "What does 1.5 V mean?"
    a. Tell the students that water flows through a hose because there is a difference in water pressure at the ends of the hose. Ask: "How can we increase the rate of flow of the water?" (By increasing the pressure difference). Ask: "How could we do this?" (Lead students to explain we might add one or more water pumps to the line or have one end of the hose much higher than the other.)
    b. In an electrical circuit, a difference in potential called an EMF causes the electrons to move or flow. It is measured in a unit called a volt, named after the Italian physicist, Volta.
3. Develop the concept of electron current flow. Ask: "How can we measure electric current?" Explain that electric current is measured in units called amperes (amps). An ampere is a measure of the number of electrons passing a point in a given amount of time.
4. Refer to circuit and ask, "What is limiting the flow of electrons in the circuit?" Explain that resistance can be defined as any condition that limits the flow of electrons in a circuit. Resistance is measured in units called ohms.

SUMMARY

1. "How does the current produced by a 1.5 V battery compare with the current in the same circuit using a 9 V battery?"

2. "Why does an electric oven use more energy than an electric toaster?"

3. "Why must a circuit be complete (unbroken) in order for a bulb to light?"

FOR FURTHER THOUGHT

. Using reference materials, describe how a scientist named Ohm related the three elements of electricity: current, voltage, and resistance.

# Lesson 4: HOW CAN THE FLOW OF ELECTRICITY BE CHANGED?

AIM: "How can we make a bulb glow more brightly?"

PERFORMANCE OBJECTIVES: The students will be able to:

- compare and contrast a variety of factors that influence the flow of electricity.
- describe some factors that influence the resistance of a wire.
- manipulate specific scientific materials in a laboratory situation.
- apply scientific principles to solve specific problems.

MATERIALS: Laboratory Worksheet 2.14 (for teacher demonstration), resistance board that contains nichrome wire #22 and #28 (2-foot lengths) or copper wire of different thickness, 1.5 volt lamp, dry cell, alligator clip.

MOTIVATION: Ask: "How can we change the rate of water flow in a garden hose?"

DEVELOPMENT (This lesson may take more than one period.)

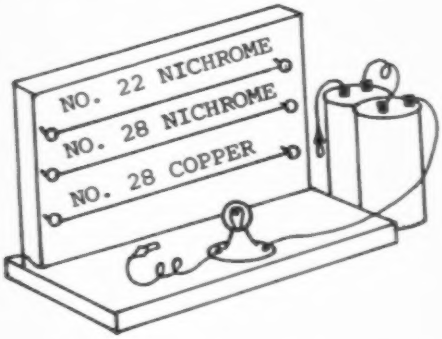
1. Demonstrate the setup for a series circuit. Caution students that the circuit must be broken when not in use.

2. Guide students through Laboratory Worksheet 2.14.

3. Circuits similar to the students' can be used in demonstrations. Ammeters and voltmeters can be added to the circuits.

4. Explain to students how the current in the circuit can be controlled.

   a. Prepare a resistance board as shown below: (Each wire should be about two feet long.)



***NOTE TO TEACHER:** The alligator clip may be moved along the #22 wire. The smaller the length of the #22 nichrome used, the smaller the circuit resistance and the brighter the lamp. The #28 nichrome wire has 1/4 the cross-section area of #22 nichrome, and thus 4 times the resistance of the same length of #22 nichrome wire. The #28 copper wire has very low resistance and the lamp will light brightly regardless of the alligator clip position.

Note the change in the bulb's brightness or substitute an ammeter for the light bulb and observe the variations in its readings.

b. Ask: "What do we mean by resistance?"

c. Ask: "What factors determine the resistance of a wire?" The electrical resistance of a wire depends upon its thickness, composition, length and temperature. A thick wire will have less resistance than a thin wire of the same material. The longer the wire the greater the resistance. The resistance of a wire will increase as the wire becomes hotter.

SUMMARY

. See Laboratory Worksheet 2.14.

# LABORATORY WORKSHEET 2.14

NAME________________________ CLASS______________ DATE__________________

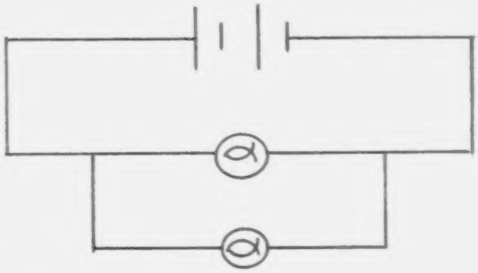
**PROBLEM:** How can the flow of electricity be changed?

**MATERIALS:** Two 1.5 V dry cells, insulated bell wire, two bulbs, two sockets, switch.

**INTRODUCTION:** Picture an apple pie. Most of us "see" the same thing. Now picture water flowing. Some of us might "see" a narrow, rapidly-moving mountain stream while others a wide, slow-moving river. Many factors can affect the flow of water. The flow of electricity can also be affected by a variety of factors. You will discover some of these factors today.

## PROCEDURE

1. Set up a circuit using the diagram below as a guide.



Note: Always place the switch in the open position when you are not making observations.

a. What is a complete circuit? ______________________________

____________________________________________________

b. Why may the battery be considered as the driving force of the circuit?

____________________________________________________

____________________________________________________

# LABORATORY WORKSHEET 2.14 (continued)

NAME ______________________________

2. Set up a circuit using two batteries connected in series to one bulb.

   a. How does the brightness of the bulb here compare to the bulb in procedure 1?

   ______________________________________________________________

   b. How can you explain the difference in the brightness of the bulb compared to procedure 1?

   ______________________________________________________________

   ______________________________________________________________

3. Set up a circuit using two batteries and two bulbs, all connected in series.

   a. Compare the brightness of the bulbs in this step to that of the bulbs in procedures 1 and 2.

   ______________________________________________________________

   b. In what way has the bulb's brightness changed?

   ______________________________________________________________

   ______________________________________________________________

4. Now partially unscrew one bulb.

   a. How does this affect the brightness of the other bulb? ____________

   ______________________________________________________________

   b. How is this similar to Christmas tree lights connected in series?

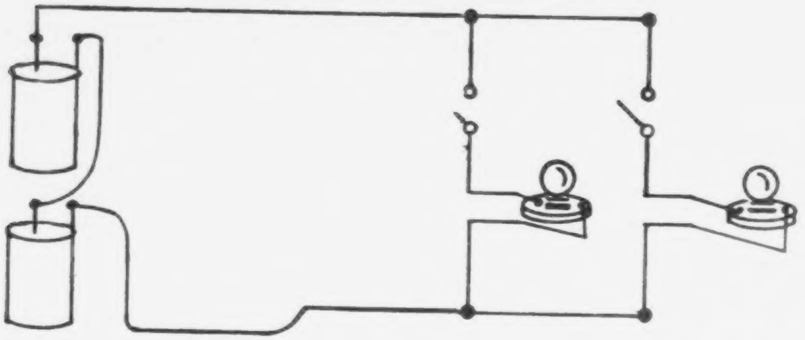
   ______________________________________________________________

   ______________________________________________________________

5. Try to make a circuit such that when one bulb goes out the other remains on. Use 2 bulbs and 2 dry cells. What is a parallel circuit? Review parallel circuits as circuits that provide more than one path for electrons to flow. (Refer to Grade 7 Curriculum Guide, pp. 91-92.)

# LABORATORY WORKSHEET 2.14 (continued)

NAME ______________________________



SUMMARY/HOMEWORK

1. Why does varying the thickness of a copper wire affect the flow of electrons?

2. Why don't all the lights in your house go out when you unscrew one?

FOR FURTHER THOUGHT

. Why is tungsten wire used in bulbs rather than copper wire of the same thickness?

## Lesson 5: HOW IS ELECTRICITY MEASURED IN OUR HOMES?

AIM: "How do we read an electric meter?"

PERFORMANCE OBJECTIVES: The students will be able to:

. relate power to electrical usage.
. read an electric meter.
. become wiser consumers of electricity.

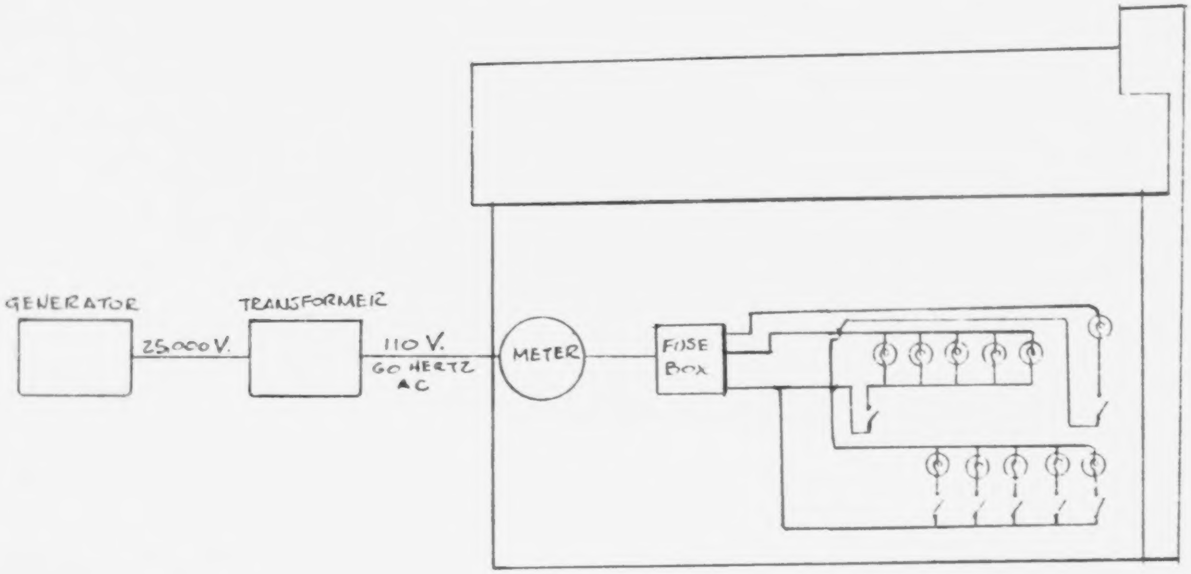
MATERIALS: Electric company bill, bulbs of different wattage, various appliances.

MOTIVATION: Ask: "How would you like to reduce your family's monthly electric bill?" "What must be understood in order to do this?"

DEVELOPMENT

1. Use diagram of power transmission to a home and add a simple diagram to show that house wiring is in parallel. Ask: "Why can we turn out a light on a circuit and not affect other working appliances?"

2. "What kind of current enters your home?" "Distinguish between AC and DC."



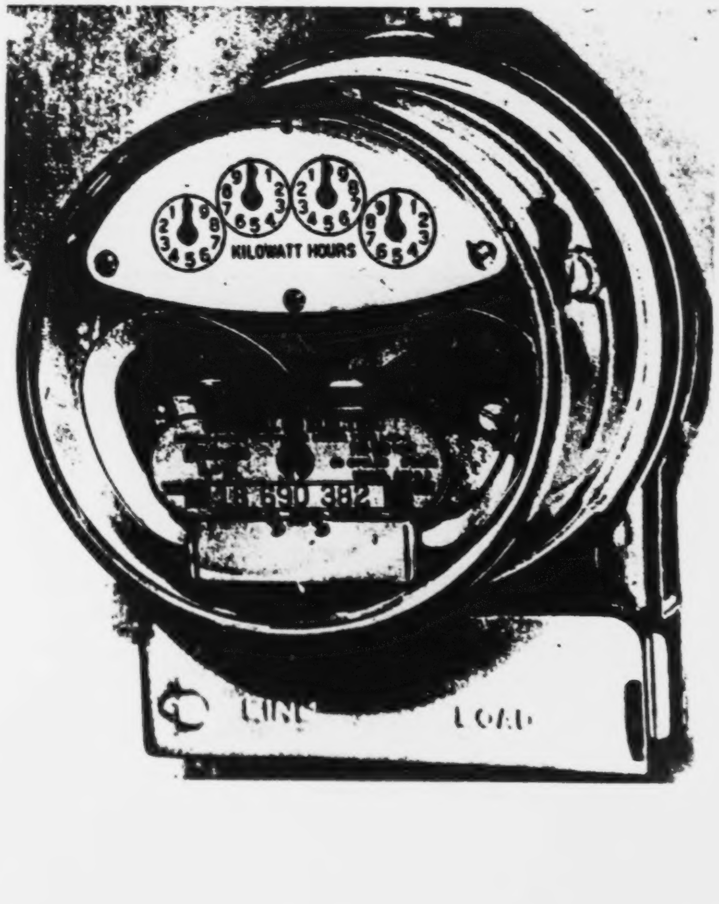
3. Define the term POWER as it applies to electricity. Develop that the power needed to run an appliance refers to the rate at which work is done (electrical usage) and is measured in WATTS (kilowatt is a more convenient term). Demonstrate various items and show listed wattage. (The energy used by a 100 watt bulb in ten hours equals 1000 watt-hours, or 1 kwh).

   a. Ask: "How does the power an item uses relate to its function?" (toaster vs. electric oven)

   b. Ask: "How have manufacturers been able to reduce the energy needed to operate some appliances?" Refer to "energy saver" cycles on some appliances.

4. Show class an electric bill. Relate kw hours used to cost per kw-hour. Con Edison charges over 11 cents per kwh and increases this to over 13 cents in the summer. Ask: "How does Con Edison know how much to charge?" "Why do they increase the rate in summer?"

5. Reproduce a meter face on the board or use a transparency of a meter and demonstrate how to read it.



## SUMMARY

1. "Why are our homes wired in parallel circuits rather than in series circuits?"

2. "What would you advise your parents to do in order to reduce their electric bill?"

3. "Why do some electrical appliances have energy saver cycles?"

4. "Why do we place fuses or circuit breakers in series with the circuits being protected?"

## FOR FURTHER THOUGHT

1. "Read your electric meter once an hour for three hours and record the readings. Why did the kilowatts used in each hour segment vary?"

2. Complete the chart below:

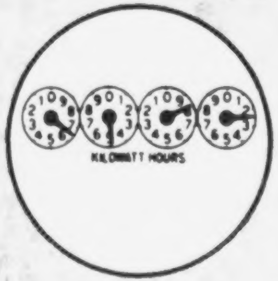
| Appliance With Wattage Listed | Watts | Kilowatts | Hours used Per day | Kilowatt-hours |
|---|---|---|---|---|
| Clock | | | | |
| Light bulb in kitchen | | | | |
| TV | | | | |
| Hair blower | | | | |

Students are to look at the applicances in order to find out how many watts they require.

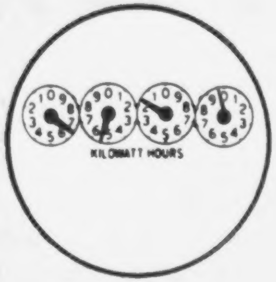
3. Explore differences between alternating and direct current.

## Electric

**A**



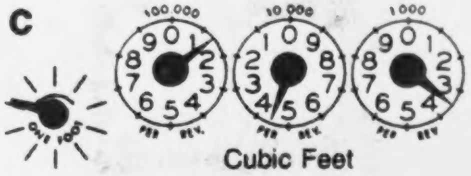
**B**



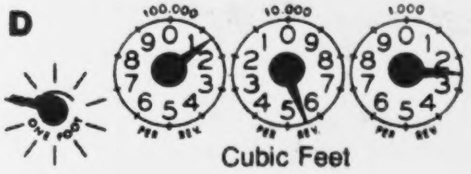
Meet Your Meters (pamphlet), Con Edison, New York, November 1981.

## Gas

**C**



**D**



## How to Read Your Electric Meter

You can read your own electric meter.

It has four dials, as shown in illustration "A" at the left. Start with dial on the left. The hand has passed 6 and is on its way to 7, so you read it as 6. You always read the smaller number. On the second dial the hand is not quite on 5, so you read it as 4. On the third dial the hand has not reached 9, so you read it as 8. On the fourth dial, the hand is between 2 and 3, so you read it as 2.

You'll note that the hands on the first and third dials move counterclockwise. The hands on the second and fourth dials move clockwise. In any case, just remember that the hands always move in the direction of the higher numbers.

The reading you get from the dials is 6-4-8-2. You write the figures down just as you read them from dial to dial, left to right.

At a later time, the meter dial hands have moved because some electricity has been used. Here, the dial hands are in the positions of those in illustration "B." This reading is 6-5-1-9. You might ask: why read the hand on the third dial as 1 when the hand looks like it is on 2? Because the hand on a dial moves fully from one number to the next only when the hand on the next dial to the right has made a complete turn from 0 to 0. The hand on the right has not made a complete turn—it had just passed 9 but is short of 0. So the hand in question on the third dial has not quite reached 2.

So how much electricity has been used?

The difference between the two meter readings—6519 and 6482—represents the amount used in this case. Subtracting 6482 from 6519 gives 37, the measure of the amount used in the time between the two readings.

On some meters, the difference between the readings must be multiplied by another figure—usually 10—to get the actual number of kilowatthours (kwh) used. This is because the hand on the last dial on the right, as in this example, advances one number for every 10 kwh used. The multiplier figure is shown on your bill. In this reading with the multiplier number of 10, the total kwh would be 370 (37 times 10).

## How to Read Your Gas Meter

Gas meters have a row of three or four dials (see illustration "C" at left with three dials—the kind on most gas meters). Other smaller dials below the row and marked with the words "one foot" (usually one dial, but sometimes two) are used for testing only, so you don't have to read them or pay any attention to them. You read the row of dials—either three or four, depending on which meter you have.

Start with the dial at the left in illustration "C" and read the last, or smaller, number passed by the hand—in this case 1. You read the second dial as 4, because the hand is between 4 and 5. In the same way you read the next dial as 3.

The dials from left to right read 143—your gas meter reading. A later reading may come to 152 as in illustration "D."

How much gas have you used?

By subtracting the first reading—143—from the second—152—you get 9, which is the number of units of 100 cubic feet, or a total of 900 cubic feet of gas you have used.

## Theme II — Questions for Review

Unit 5. Electrical Energy

NAME ______________________________ CLASS __________ DATE __________________

1. Rubbing one substance against another causes a:
    a. loss of neutrons
    b. loss of protons
    c. transfer of electrons
    d. gain of protons

2. An electroscope contains two thin pieces of metal foil called:
    a. switches
    b. terminals
    c. branches
    d. leaves

3. A bolt of lightning produces thunder because:
    a. the electrons ionize the air
    b. protons are released
    c. large waves of light are produced
    d. the heat produced ignites the air

4. Insulators:
    a. conduct electrons
    b. can hold a static charge
    c. cannot hold a static charge
    d. conduct protons

5. Control of an electric current is provided by:
    a. a lamp
    b. a switch
    c. a source
    d. resistance

6. An example of an automatic protective device used in an electric current is:
    a. a fuse
    b. resistance
    c. load
    d. a switch

7. In a series circuit, electrons:
    a. do not flow
    b. flow along several paths
    c. are produced
    d. flow along a single path

8. Kilowatts measure:
    a. energy
    b. power
    c. current
    d. resistance

9. The potential difference produced by a battery is measured in:
   a. amperes
   b. fuses
   c. volts
   d. ohms

10. Current follows a complete, closed path called a(n):
   a. wire
   b. insulator
   c. fuse
   d. circuit

11. Mary rubbed a balloon against her hair. She then placed the balloon against the wall where it clung. This occurred because:
   a. the balloon lost protons
   b. electrons were transferred from her hair to the balloon
   c. an electric current was produced in the wall
   d. before she rubbed the balloon, there was a voltage difference between Mary's hair and the balloon.

12. An electric charge that is NOT in motion is:
   a. static electricity
   b. current electricity
   c. an electron flow
   d. a protective device

13. A charged rod was touched to an electroscope's rod and the thin pieces of metal foil moved apart. We can conclude that:
   a. the rod was positively charged
   b. the rod was negatively charged
   c. the rod was uncharged
   d. the pieces of metal foil acquired the same charge

14. An electroscope's pieces of metal foil were far apart. Patty touched the electroscope's knob with her finger. The metal foil pieces came together. We can conclude that:
   a. the electroscope was discharged by Patty's finger
   b. Patty's finger charged the electroscope positively
   c. Patty's finger charged the electroscope negatively
   d. Patty's finger was charged

15. A flow of electrons from minus to plus is:
   a. static electricity
   b. an electron current
   c. present in all wires
   d. possible only if a battery is used

NAME ____________________________

16. Wire A has a thickness of 1 inch, and wire B has a thickness of 2 inches. Both wires are made of copper, and are 8 inches long. The wire with the greater resistance is wire:
    a. A
    b. B
    c. the wire with the thickest insulation
    d. the wires have the same resistance

17. Wires C and D are made of the same material. They will have the same resistance if they have the same:
    a. length
    b. thickness
    c. temperature
    d. all of the above

Questions 18 - 22 are based on the following:

Jose had 2 identical bulbs, 3 dry cells, some wire, and a switch. He connected all those materials to form a circuit. The switch was then closed.

18. The bulbs glowed with equal brightness. The type of circuit that Evan had connected was:
    a. a series circuit
    b. a parallel circuit
    c. either series or a parallel is possible
    d. an open circuit is possible

19. The bulbs would glow more brightly if:
    a. more voltage were added to the circuit
    b. a battery were removed
    c. another bulb were added in series with the other two
    d. the resistance of the wires was increased

20. By decreasing the resistance of the wires, the current in the circuit would:
    a. increase
    b. decrease
    c. be unaffected
    d. be zero

21. Jose removed one of the bulbs in the circuit. The other bulb went out. The type of circuit was:
    a. series
    b. parallel
    c. either series or parallel
    d. short circuit

22. Jose took the circuit apart and then connected the equipment a different way. When he removed one bulb, the other bulb remained glowing. This type of circuit was a(n):
    a. series
    b. parallel
    c. either series or parallel
    d. open circuit

NAME ____________________________

## Matching

| Column A | Column B |
|---|---|
| 23. Unit of electron flow | a. ammeter |
| 24. Electrons in motion | b. static electricity |
| 25. Electric charge at rest | c. voltmeter |
| 26. Device that measures current | d. ampere |
| 27. Device that measures emf | e. electric current |

## True or False

28. ________ When an object loses electrons it takes on a positive charge.

29. ________ Electrical resistance is measured in units called ohms.

30. ________ A device used to change the voltage entering it is called a generator.

31. ________ When electrons make one back and forth trip in an alternating current, they have completed one cycle.

32. ________ A flow of electrons traveling in one direction in a circuit is known as direct current.

## Explain

33. Why will someone get a shock from touching a metal doorknob after walking across a wool carpet?

34. Why are lights and appliances in a home wired in parallel?

35. Draw a diagram of a simple series circuit. Label all parts.

36. Why are fuses or circuit breakers made a part of electric circuits in homes?

# UNIT 6. INSURING OUR ENERGY FUTURE

# Pretest

Unit 6 - Insuring Our Energy Future

NAME ______________________________ CLASS __________ DATE __________________

1. A fuel that originated from animals and vegetables is:
   a. coal
   b. oil
   c. natural gas
   d. all of the above

2. The original source of energy in all fossil fuels is:
   a. oil
   b. coal
   c. gas
   d. the sun
   e. uranium

3. Shale is a substance that traps oil in reservoirs. This means that shale is:
   a. porous
   b. non-porous
   c. a metamorphic rock
   d. similar to sandstone

4. Plant and animal remains formed oil, but a necessary factor was:
   a. long periods of time
   b. heat
   c. pressure
   d. all of the above

5. Natural gas is often found above petroleum. This means that natural gas:
   a. formed before the petroleum
   b. formed after the petroleum
   c. is heavier than petroleum
   d. is less dense than petroleum

6. The most dense type of coal is:
   a. lignite
   b. hard coal
   c. soft coal
   d. peat

7. When coal is ignited:
   a. heat causes the formation of gases which burn
   b. soft coal burns completely leaving no impurities in the air
   c. the carbon burns completely as a solid
   d. a liquid forms which burns easily

NAME ______________________________

8. A problem with the use of oil as a fuel is that:
    a. oil produces radiation similar to uranium
    b. we cannot produce the necessary pressure to produce more oil
    c. burning oil causes air pollution
    d. all of the above

9. We cannot produce unlimited amounts of petroleum and gas because:
    a. it takes millions of years, under the proper conditions, to produce fossil fuels
    b. we do not possess the financial resources necessary
    c. the Middle East is the only area on earth with the proper environment to form petroleum and gas
    d. the political climate presents too many problems

10. A problem presented by natural gas is:
    a. it is difficult to ignite and burn
    b. natural gas has a tremendous volume
    c. it is not as good a method of heating as electricity
    d. it can be liquidfied easily

11. 20g. of anthracite is more dense than 20 g. of peat. This means that 20g. of antracite:
    a. has a smaller volume than 20g of peat
    b. has a greater volume than 20g of peat
    c. has the same volume as 20g of peat
    d. has a smaller mass than an equal volume of peat

12. Sue had 3 identical, empty shoe boxes. She filled one box with cotton, one with lead, and the other with dimes. The box that was most dense was the box containing:
    a. cotton
    b. dimes
    c. lead
    d. the densities were equal for all three boxes

13. An example of a chain reaction is:
    a. an explosion
    b. a neutron bombards a nucleus which produces energy and two additional neutrons
    c. two nuclei fuse to form a new nucleus
    d. the breakdown of atomic structure

14. The factor needed to sustain a chain reaction is the:
    a. critical mass
    b. energy required to break-down uranium into barium
    c. energy required for the outermost energy level electron to be lost or gained
    d. energy required for a endothermic or exothermic reaction

NAME ______________________

15. One benefit of nuclear reactors is they:
    a. are safer than conventional energy generators
    b. create an enormous supply of heat energy
    c. produce the necessary background radiation
    d. all of the above

## Lesson 1: WHAT ARE FOSSIL FUELS?

AIM: "What causes coal to burn?"

PERFORMANCE OBJECTIVES: The students will be able to:

- trace the formation of oil, coal, and natural gas from living materials to end product.
- demonstrate an awareness of the long period of time necessary for fossil fuels to form.
- reason inductively and deductively.

MATERIALS: Assorted fossils, samples of coal, samples of permeable and impermeable rocks, burner.

MOTIVATION: Display a small piece of coal and another small mineral. Place each in a flame. Ask the students to describe what they observe.

DEVELOPMENT

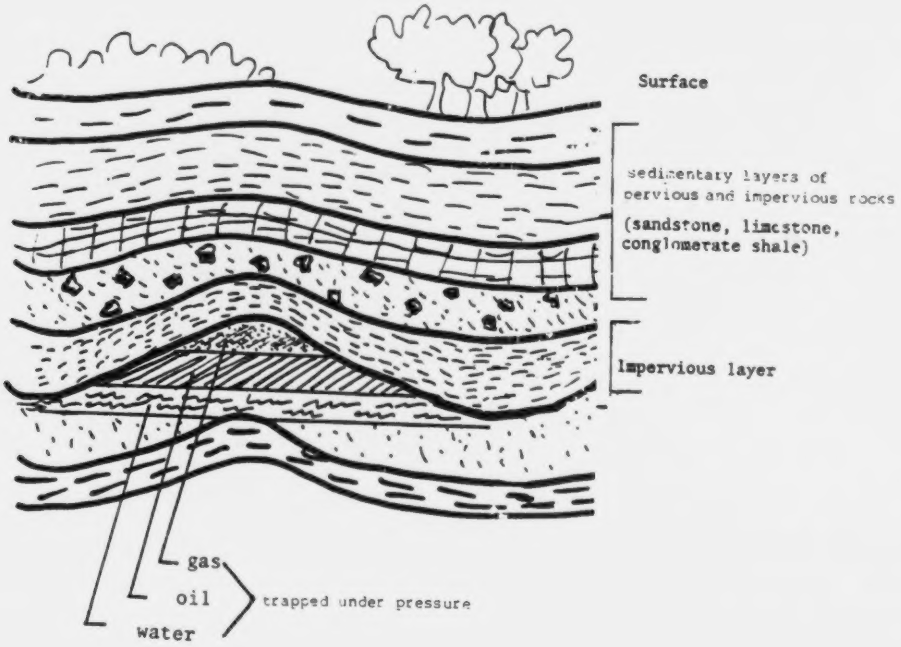
1. Ask: "How do you explain the fact that one substance burned, but the other did not?" Elicit the fact that the substances differed in composition. Have the students speculate on the composition of the substance that burned. They will recognize it as coal.

2. Show some examples of fossils. Ask: "Why are oil, coal, and natural gas considered fossil fuels?" Elicit because of their animal and vegetable origin. Plants and animals that lived hundreds of millions of years ago trapped energy from the sun as they made food. The organisms died and their remains decayed. As time passed, the plant and animal remains became coal, oil, and natural gas. These fuels are known as fossil fuels because they formed from the remains of fossil organisms. Burning fossil fuels releases the energy organisms obtained from the sun long ago.

   Liquid fossil fuel is petroleum or oil.

3. Refer to the diagram below:

A Typical
Oil and Natural Gas Formation


Surface
sedimentary layers of pervious and impervious rocks
(sandstone, limestone, conglomerate shale)
Impervious layer
gas
oil
water
trapped under pressure

4. Discuss the formation of oil and gas pockets within the earth.

   a. Ask: "How do bacteria, heat, and pressure affect plant and animal remains?" Elicit that bacteria, heat, and pressure can convert plant and animal remains into oil. Tell the students that oil droplets seep into pores and cracks of rocks, eventually forming oil pools.
   Ask: "Why are oil pools usually found in sandstone and shale formations?" Relate this to the diagram. The sandstone is pourous and allows oil to seep through but the shale is impervious or nonporous, and traps the oil in reservoirs.

   Ask: "Why is natural gas often found with petroleum?" Since it is lighter than petroleum, it rises and is found on top of the oil pool. Discuss the formation of oil and gas pockets within the earth.

   b. Review why oil is usually found below an impermeable layer.

   c. Develop the concept of definite periods of time in geological history when portions of the earth were covered by swamps and fossil fuels were formed. Tell the students that oil formation began approximately 600 million years ago, and continued to form for a few more million years.

d. Heat and/or pressure can alter the characteristics of rocks. This process is called metamorphism. Relate this term to the formation of fossil fuels such as anthracite coal.

   Rocks that have been changed from one type of rock into another are called metamorphic rocks. Metamorphic rocks begin to form at temperatures of 100°C to 200°C. They continue to form at temperatures of up to 600°C or 800°C. The tremendous pressure that these minerals are under tends to squeeze the molecules together to form denser minerals.

5. Return to the burning coal demonstration during the Motivation. Tell the students that coal formation began about 350 million years ago. This was the Paleozoic Era. Towards the end of this era, much of the earth's land was covered by thick forests with shallow swamps. The climate was warm and humid.

   a. Ask: "How could such conditions result in coal formation?" Trees died and fell into swamps. Bacterial action decayed the trees. Mud and sand washed over them to prevent complete decay. Sedimentary rocks eventually formed. Over millions of years, the earth buckled and changed. Great pressure was placed upon the partially decayed plants. Chemical and physical changes left almost pure black carbon, call coal.

   b. Compare the types of coal: hard, soft, lignite, peat, and coke (depending upon varying amounts of heat and/or pressure.)

SUMMARY

1. "Why are fossil fuels considered to be a nonrenewable resource?"

2. "Trace the energy in fossil fuels back to the sun."

FOR FURTHER THOUGHT

- "Why might the Everglades of Florida be a potential source of oil in the very distant future?"

## Lesson 2: HOW CAN WE PUT FOSSIL FUELS TO WORK FOR US?

AIM: "How can plants, twigs, and leaves be used as fuel?"

PERFORMANCE OBJECTIVES: The students will be able to:

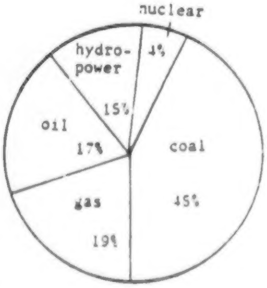
- enumerate ways fossil fuels are used by man.
- explain that when coal is ignited, the heat causes the coal to form gases, which burn easily and leave carbon.
- apply specific learnings to new situations.
- reason inductively and deductively, based upon specific class experiences.

MATERIALS: Burner; ring stand and clamp; flask; one-holed stopper; about six inches of glass tubing with a 45 degree bend; small pieces of plants, twigs, and leaves.

MOTIVATION: Light the burner under the flask containing the small pieces of plants, twigs, and leaves. A gas should form which will pass through the glass tubing in the stopper. Carefully ignite the gas.

DEVELOPMENT

1. Ask the students to describe what they observed and have them explain it. (Burning the small pieces of plants, twigs, and leaves produces a combustible gas.)
   a. Ask: "How did the materials in the flask produce a fuel?" The students should explain that the molecules which composed the plants, twigs, and leaves broke down into smaller molecules because of the heat applied and formed a volatile gas which burned easily.
   b. Ask: "How does coal burn?" Lead the students to apply the manner in which gas was formed by burning the materials in the flask to the burning of coal. (The fuel combines with oxygen to yield heat energy and by-products.)
2. Discuss the use of fossil fuels as energy sources and relate this to the production of electricity and/or heat in power plants (industrial and home).



Fuels which produce electric power

3. Relate fossil fuels to a variety of consumer products. Ask: "What does a barrel of oil have in common with a plastic ruler?"

   Construct a list of common articles that are made from oil. Include such items as fertilizers, gasoline, tar, benzene, turpentine, paints, rubber products, etc.

4. Ask: "Why was 1973 considered to be a crisis year in the history of energy?"

SUMMARY

1. "Why is coal used as the chief source of energy in the production of electricity?"

2. "Why does the cost of electricity increase when the cost of fossil fuels goes up?"

FOR FURTHER THOUGHT

. "What are the relative advantages and disadvantages of using each of the fossil fuels (oil, coal, natural gas) in terms of:

1) storage, 2) cost, 3) efficiency, and 4) environmental effect?"

## Lesson 3: TO WHAT PROBLEMS DOES THE USE OF OIL AND GAS LEAD?

AIM: "Why is oil called the fuel of choice today?"

PERFORMANCE OBJECTIVES: The students will be able to:

- cite the advantages of using oil as an energy source.
- discuss some reasons why oil and gas use presents problems.
- evaluate positions on a major, current issue.

MATERIALS: None.

MOTIVATION: "The United States uses more than five billion barrels of oil per year. There are an estimated 68 billion barrels available in the ground in the U.S. What problems do you see?"

DEVELOPMENT

1. Reproduce the following chart on the chalkboard.

HEAT ENERGY PER POUND OF COMMON FUELS

| Fuel | Heat Energy (BTU) |
|---|---|
| gas | 20,000 |
| oil | 19,600 |
| coal | 12,500 |
| wood | 5,000 |

Explain that the letters BTU stand for the British Thermal Unit. This is an amount of heat energy that will warm one pound of water 1°F.

Ask: "Why is oil the fuel of choice in today's industrial world?"

2. Develop reasons for present oil problems (demand greater than supply, industry geared to using oil, unstable and unfriendly countries are major oil producers, cost of shipping, cost of drilling new wells, etc.).

3. Inform students that since 1900, energy use in the United States has increased tenfold. Today, the United States uses nearly 30% of all the fossil fuel energy produced in the world. It uses over five billion barrels of oil each year.

   Petroleum and gas reserves in the earth are limited. Reserves are the unused fossil fuel deposits left in the earth. At the present rate of use, the United States may run out of fossil fuel by the year 2060. By the year 2080, the world supply may run out. Ask: "How do you think this will affect living conditions?"

4. Ask: "In what other ways is oil used in our country?" (plastics, fertilizers, pharmaceuticals, chemicals, etc.)

5. Ask: "What are some pollution problems associated with oil?" Discuss refining and its effects on the land. "Is it an ugly blot on the landscape or a magnificent technological and chemical wonder?" Have the students mass the effects of visual pollution and terrible odors against the production of useful products. Briefly discuss air pollution.

6. Ask: "What problems are raised by natural gas?" (Shipping gas presents a special space problem because gases occupy a tremendous volume because their molecules are so far apart. Relate this to the Kinetic Molecular Theory.)

7. Ask: "How can we solve the problem of volume?" (If a gas is cooled or frozen, molecules are moved closer together, causing the gas to liquify.)

8. Ask: "What problems does liquefying the gas produce?" (Problems with shipment. Many communities are opposed to trucks carrying liquid natural gas. Gas creates serious environmental problems. There are spills in the water where oil and gas exploration occurs. Liquid natural gas tankers may spill gas, creating a "fireball" on the ocean. Gas also produces poisonous wastes upon burning.)

SUMMARY

. Have students write a paragraph on "How I Would Solve the Present Oil Problem." Read and discuss some student responses.

FOR FURTHER THOUGHT

. "Why have oil-producing countries become a dominating factor in today's world?" "How has the Alaskan pipeline made more oil available?"

## Lesson 4: WHAT ARE SOME PROPERTIES OF COAL?

AIM: "How do the coal samples differ?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe the characteristics of various forms of coal.
- apply the skill of mass determination.
- determine the relationship between mass and volume.

MATERIALS: See Laboratory Worksheet 2.15.

MOTIVATION: "What is the most widely found fossil fuel?"

DEVELOPMENT

1. Ask: "Why is coal the most widely found fossil fuel?" Elicit that coal is the most readily formed fossil fuel because its formation requires simpler chemical and physical processes than other fossil fuels.

2. The teacher should introduce the concept of density since the concept may not have been taught to all of the students.

SUMMARY

1. "Why would a shoe box filled with cotton be less dense than the same shoe box filled with buttons?"

2. "How would Superman change peat moss into coal?"

   Density is defined as the mass per unit volume of material and is found by using the equation:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

   Mass may be expressed in grams. Volume, the amount of space occupied by the substance, may be expressed in cubic centimeters.

FOR FURTHER THOUGHT

- "How is it possible that a kilogram of lead has the same density as only a gram of lead?"

# LABORATORY WORKSHEET 2.15

NAME________________________________ CLASS__________ DATE_______________________

**PROBLEM:** What are some properties of coal?

**INTRODUCTION:** Coal is the most abundant source of fossil fuel energy in the United States. In this investigation, you will take a close look at several types of coal. You will see evidence of how it was formed.

**MATERIALS:** Chunks of peat moss, bituminous coal, anthracite, newspaper or paper towels, hammer, coarse white paper, triple beam balance.

**PROCEDURE**

1. Cover your work area with newspaper or paper towels. Take care to protect your clothing.

2. Examine a piece of each type of coal and complete the chart below:

| Name | Color | Texture | Hardness | Special Features |
|---|---|---|---|---|
| Peat | | | | |
| Bituminous coal | | | | |
| Anthracite coal | | | | |

3. Rub a sample of each on a piece of white paper.

   a. Why is peat considered to be an early stage in the development of coal?

   ______________________________________________________________

   ______________________________________________________________

   b. What evidence did you find to show that coal is formed in layers?

   ______________________________________________________________

   ______________________________________________________________

# LABORATORY WORKSHEET 2.15 (continued)

NAME ____________________________

4. Mass 20 g of each form of coal.

   a. Which sample has the greatest volume? ________________________________

   b. In which sample are the molecules the farthest apart? ________________

   c. The relationship between an object's mass and its volume can be expressed using the equation:

   $$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

   How would you explain why 20 g of anthracite is more dense than 20 g of peat?

SUMMARY/HOMEWORK

1. Why would a shoe box filled with cotton be less dense than the same shoe box filled with buttons?

2. How could Superman change peat moss into coal?

3. Since one gram of water occupies a volume of 1 $cm^3$, its density is said to be 1 gram per $cm^3$. What would be the density of 100 grams of water under the same conditions? ________________________________

## Lesson 5: HOW CAN WE CONSERVE ENERGY?

AIM: "Why did the United States lower the maximum highway speed to 55 m.p.h.?"

PERFORMANCE OBJECTIVES: The students will be able to:

- justify the need to conserve energy.
- relate the roles of government, industry, and consumers in conserving energy.
- formulate a list of varied conservation problems.

MATERIALS: None.

MOTIVATION: Have students write a paragraph to explain the following statement:

"The United States has 5 percent of the world's population and uses 30 percent of the world's fossil fuels."

Have several students read their paragraphs aloud.

DEVELOPMENT

1. Information for possible distribution:

Uses of Oil in the United States

| | |
|---|---|
| Transportation | 55% |
| Home heating | 20% |
| Industry | 17% |
| Electric power | 8% |
| | 100% |

Uses of Coal in the United States

| | |
|---|---|
| Electric power generation | 65% |
| Export | 13% |
| Steel industry | 11% |
| Chemical & industrial plants | 10% |
| Home heating | 1% |
| | 100% |

2. Ask: "What does conserve mean?" (It means to save from loss or waste.) Discuss short-range and long-range energy conservation goals.

   a. Short-range goals include accomplishing our work with present energy supplies. Because of world political and economic conditions, this may be difficult unless we decrease our energy use.

   b. The long-range goal is to develop new energy sources, and increase the efficiency of existing sources. We must use less energy and use it more efficiently.

3. Ask: "What does the expression 'gasification of coal' mean?" Assuming it can be achieved on a large scale, how would coal gasification decrease our dependence on foreign imports of oil?

4. Discuss the roles of each of the following in conserving energy:

   a. Government (regulations, price controls, tax incentives, legislation)

   b. Industry (improving industrial processes, recycling products for raw materials, producing more efficient appliances and vehicles)

   c. Individuals (conserving electricity, improving insulation, using less gasoline, using mass transit)

SUMMARY

1. "What are two reasons for conserving energy?"

2. "What are several ways you can conserve energy?"

FOR FURTHER THOUGHT

1. "How have the government and private industry attempted to make the public aware of the energy crisis and the need to conserve?"

2. "What additional methods of increasing public awareness can you recommend?"

# Lesson 6: HOW DOES A NUCLEAR REACTOR WORK?

AIM: "Are nuclear reactors dangerous?"

PERFORMANCE OBJECTIVES: The students will be able to:

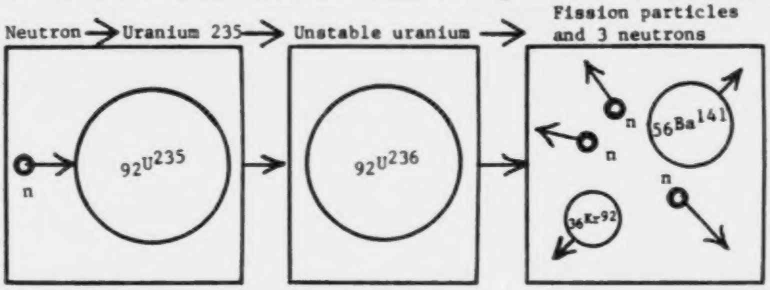
- explain the design and operation of a nuclear reactor.
- evaluate the possible hazards associated with a nuclear reactor.

MATERIALS: Dissectible model of a nuclear reactor or a diagram of a nuclear reactor.

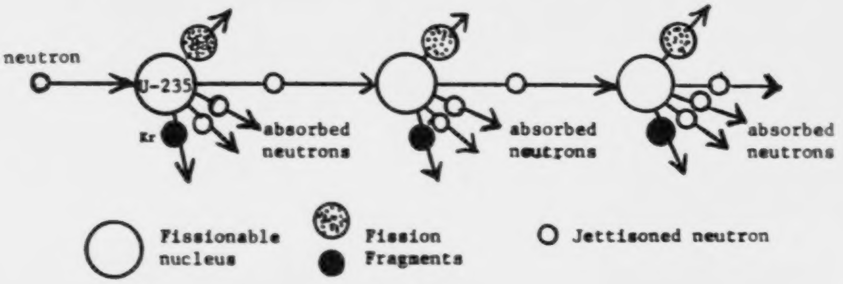
MOTIVATION: Ask: "What could happen to you if a nuclear reactor were to be built a few blocks away from this school?"

DEVELOPMENT

1. "How does a controlled nuclear reaction produce useful energy?"

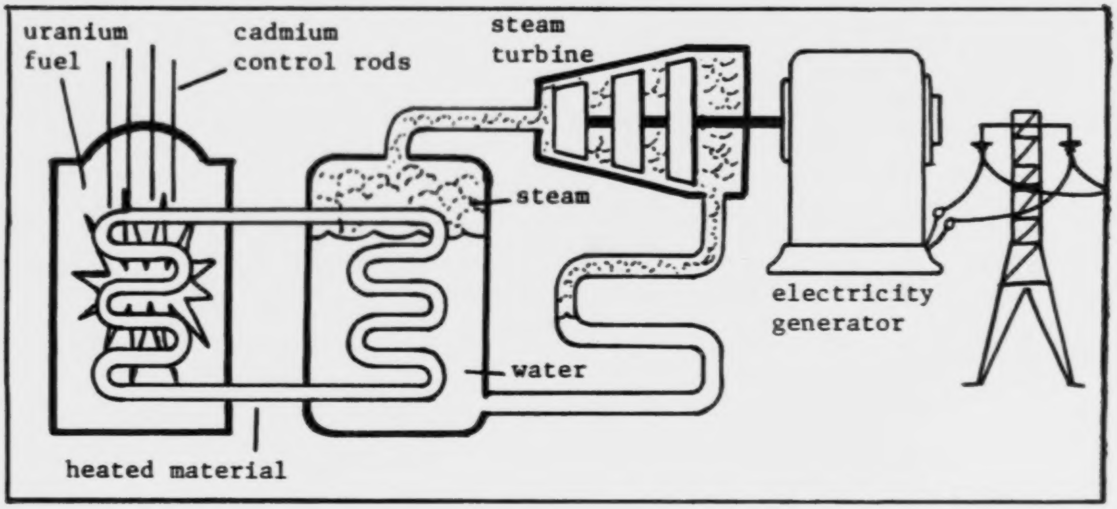

Neutron
Uranium 235
Unstable uranium
Fission particles and 3 neutrons
n
$_{92}U^{235}$
$_{92}U^{236}$
n
n
$_{56}Ba^{141}$
n
$_{36}Kr^{92}$

Explain that a slow moving neutron can be captured by a nucleus of uranium 235 and create the unstable isotope, uranium 236. Fission soon occurs and the U-236 breaks up into krypton 92, barium 141 and three additional neutrons. Also, a great deal of energy is emitted in the process.


neutron
U-235
Kr
absorbed neutrons
absorbed neutrons
absorbed neutrons
Fissionable nucleus
Fission Fragments
Jettisoned neutron

If one or more of the three released neutrons encounters another atom of uranium 235, the process is continued as a chain reaction, releasing more energy and free neutrons. If too many of these free neutrons are captured by U-235 atoms, an uncontrolled reaction occurs causing an enormous release of energy producing an atomic bomb. However, if excess neutrons are absorbed, the reaction can be controlled and useful energy can be produced.

2. "How does a nuclear reactor produce useful energy?"


uranium fuel
cadmium control rods
steam turbine
steam
electricity generator
water
heated material

Explain that cadmium is an element that will absorb free neutrons. When cadmium rods are inserted into a pile of uranium fuel, they absorb neutrons, controlling the rate at which energy is produced.

The energy coming from the uranium is accompanied by dangerous radiations. To extract the energy without these radiations, a material is circulated in pipes between the fuel pile and a water tank where steam is generated. The non-radioactive steam operates turbines that generate electricity.

3. Elicit from the students the hazards that can develop if there is a malfunction in the nuclear generator.

   a. Ask: "What would happen if the cadmium rods were pulled out too far?"

   b. Ask: "What would happen if the concrete barrier around the fuel pile were to break?"

   c. Ask: "What would happen if the pipe connecting the fuel pile and the steam generator were to leak?"

## SUMMARY

1. "How can nuclear energy be used to produce electricity?"
2. "What is the difference between a controlled and an uncontrolled reaction?"
3. "Why is there a controversy about building nuclear power plants?"

## FOR FURTHER THOUGHT

- "You are an advisor to the president of the United States. Write a brief memo to him on the advantages or the disadvantages of building more nuclear power plants. Be prepared to defend your stand in class tomorrow. You may use the information gathered from the 'Student Poll on Nuclear Issues' to enhance your argument. The cumulative data from this poll may be placed on the chalkboard and a student debate may be organized."

NOTE TO TEACHER: The concepts in this lesson are difficult ones and this lesson, with its subsequent student debate, will take more than one period.

# STUDENT POLL ON NUCLEAR ISSUES

NAME ______________________________

Directions: Place a check (/) in the column that most closely represents your opinion on each of the nuclear issues stated below.

| NUCLEAR ISSUES | Agree | Strongly Agree | Disagree | Strongly Disagree | Not Sure |
|---|---|---|---|---|---|
| 1. The most pressing global issue of our time is the threat of nuclear war. | | | | | |
| 2. Someday, somewhere, someone will "push the nuclear button." | | | | | |
| 3. In war, the use of any weapon, including nuclear weapons, is justified. | | | | | |
| 4. The decision to use nuclear weapons should be based on military and political rather than moral consideration. | | | | | |
| 5. Considerations of morality (right and wrong) should influence scientists when they develop new weapons. | | | | | |
| 6. The Soviet Union today is superior to the United States in nuclear weapons. | | | | | |
| 7. The Soviets are out to conquer the world. | | | | | |
| 8. The United States should destroy the Soviets rather than allow communism to spread. | | | | | |
| 9. When the Soviets build more and better nuclear weapons, the United States must do the same. | | | | | |
| 10. Today it is possible to wage a "limited" nuclear war. | | | | | |

## Lesson 7: HOW DOES THERMAL POLLUTION AFFECT LIVING THINGS?

AIM: "How does water temperature affect a Daphnia's heartbeat?"

PERFORMANCE OBJECTIVES: The students will be able to:

- define thermal pollution.
- describe the effect of thermal pollution on life in a lake.
- explain the relationship between heat and life processes.

MATERIALS: Daphnia, bioscope (microprojector), cold water, warm water, thermometer.

MOTIVATION: What would happen to you if the average temperature of the earth increased from 20°C (at present) to 45°C?

DEVELOPMENT

1. Place Daphnia under a bioscope. Determine the number of heartbeats per second in cold water. Then count again using warm water.

2. Record the observation.

| Trial | Heartbeats per second Temperature 1 | Heartbeats per second Temperature 2 |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

3. Compare the average rate of heartbeat at low temperature with that at the higher temperature.

4. Elicit from the students:

    a. the need for more than one trial at each temperature.
    b. the need for a controlled experiment.
    c. factors other than heat that may change the rate of heartbeat.

SUMMARY

1. Ask students to read the attached material and write a paragraph on what happens in a lake as the temperature of the water increases.

2. Encourage students to suggest various possible sources of thermal pollution (water discharged from nuclear cooling systems, air conditioning plants; also natural pollutants such as meteorites, volcanic lava, and hot springs).

# STUDENT SHEET

## WATER TEMPERATURE IN A LAKE

### Algae in Lakes

Algae, which are simple plants, provide a source of food for simple, plant-eating lake animals. Algae in a cool water lake may include: green algae, blue-green algae, and diatoms. Diatoms in particular provide a good source of food for algae-eating orgnaisms. Blue-green algae, on the other hand, can produce a bad smell and taste in the water. A good supply of algae will provide plant-eating animals with an adequate food supply. These animals will in turn be eaten by larger and larger animals--smaller fish, larger fish, frogs and turtles.

### Water Temperature Preferences of Lake Animals

Some lake animals can survive a wide range of water temperatures, while other animals require a very specific water tempertaure. Animals will try to locate themselves in a lake according to these temperature needs. Trout, for example, need cold water, while many young fish (minnows, for example) are found in the warmer waters. Since colder water is more dense than warm water, colder water is usually found at the bottom of a lake and warmer water is found near the surface or in the shallow areas.

### The Effect of Increased Water Temperature on Life in a Lake

The addition of heat energy to a lake will warm the water and thereby extend the active growing season of the plants living in the lake. The additional heat will also speed up the metabolism and other life functions of these organisms. Their faster growth rate eventually results in an increased death rate.

### The Effect of Temperature on Gases Dissolved in Water

Cold water can usually hold more dissolved gases (air, oxygen, carbon dioxide, etc.) than warmer water. As a body of water warms it loses more and more of its dissolved gases. The loss of dissolved oxygen will affect fish and other animals that depend on this oxygen supply. Similarly, the loss of dissolved carbon dioxide may have a harmful effect on the growth of aquatic plants. Therefore, the death rate of these organisms will increase. Bacteria will use up even more of the dissolved oxygen as they decompose the dead bodies of fish and other organisms.

# Lesson 8: HOW CAN WE HANDLE THERMAL POLLUTION CAUSED BY A POWER PLANT?

AIM: "What is the best way of cooling a nuclear reactor?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe three methods of cooling a power plant.
- compare the ecological and economic effects of the three methods.

MATERIALS: Data sheets included with this lesson.

MOTIVATION: "What would you do if your neighbor was burning garbage and the odors and smoke drifted into your windows every night?"

## DEVELOPMENT

1. Ask the students to read the attached data sheets.

2. Refer to the lesson on the biological effects of thermal pollution. Ask the students to examine the environmental consequences of each of the three ways of cooling the power plant.

3. Prepare the students for a town council meeting on the topic "Should we allow an atomic power plant in our community?"

4. The teacher can select students for the following roles:

   (Note - ask the students to dress appropriately for the meeting.)

   a. two electric company representatives
   b. two industrial company representatives
   c. two environmental group representatives
   d. two labor union representatives
   e. two home owners

## SUMMARY

- "Ask students to list one advantage and one disadvantage of each method of handling thermal pollution."

## Student Sheet

# THE ELECTRIC ATOMIC PLANT

The plant would be a modern atomic power station producing 50% more waste heat than a conventional plant. There will be no smoke, dust, or odors given off as in normal coal, oil, or gas units. The plant will use lake water to cool its steam unit and return the water to the lake about 25° hotter causing the overall lake temperature to rise 1°F.

There are two other ways the plant could cool off its equipment besides direct flow. These are the cooling pond and cooling tower methods. The direct flow method uses large quantities of lake water and is the least expensive method. All the excess heat would go into the lake, but this method would keep the cost of building and operation down.

The cooling pond method uses a large man-made lake or pond filled with water taken from the lake by pumps. These very large ponds require large amounts of land to be purchased, dug out, and flooded at great expense. The water from the deep end would go into the plant and hot water would be pumped into the shallow end allowing it to cool off before it goes back to the deep end. This could affect the natural water table and requires a very special type of geologic land structure.

Cooling towers can be used to cool water in atomic plants. In the dry cooling tower, hot water is pumped through closed pipes with fans on them. As fans blow air past these pipes the heat is allowed to transfer into the air. In wet cooling towers, heated water is pumped and sprayed over metal plates. As air is forced by fans over the plates the water evaporates and is cooled. These towers do not affect the temperature of the lake but do change the atmosphere by adding heat and/or water vapor. A wet tower costs about 25 million dollars to build and a dry tower 50 million dollars. These very high costs would have to be passed along to the user.

# ENVIRONMENTAL DATA SHEET

## LAKE DATA

The lake is a very small one, with very little water movement. It supplies drinking water for the community. The algae grows near the surface for seven months of the year. Sunlight penetrates the water to a depth of four feet, with summer temperatures of 21°C. The cool temperature allows for a good supply of dissolved oxygen and carbon dioxide. There is an overpopulation of biomass in the lake which is causing it to fill up as the living matter dies. The presence of algae causes the water temperature to be a little high due to the sun's rays being absorbed.

Industrial and farming waste supplies the lake with large quantities of growth materials causing the lake to age rapidly. This has caused the clear water depth to become one half what it was 20 years ago. The lake is used for recreation, city and industrial sewage.

The present electrical power plant uses the lake water to cool it through pipes at the 50 foot level of the lake. The new proposed plant would double that depth and use up to seven times the amount of water.

## ECONOMIC DATA

To construct the plant local workers and materials would be used wherever possible. This means an influx of 40 million dollars into the community. The construction would give 1,500 workers employment after the plant was put into operation. The payroll would be about 20 million dollars and the supplies would cost 25 million dollars. The city would receive new tax monies.

The cost of electricity would remain at a low level giving an opportunity for influx of new industry and business.

## Lesson 9: HOW CAN WE DEAL WITH ENVIRONMENTAL CHANGES THAT ACCOMPANY INDUSTRIAL DEVELOPMENT?

AIM: "How would building an atomic power plant on our town's lake affect us?"

PERFORMANCE OBJECTIVES: The students will be able to:

. examine data from different points of view.
. evaluate the data to form a conclusion.

MATERIALS: Data sheets distributed with Lesson 8.

MOTIVATION: "Should we allow an atomic power plant to be constructed in our community?"

DEVELOPMENT

1. Discuss with the class some of the areas of concern involved in deciding to build an atomic power plant on the town's lake.

   a. The industrial need of communities for jobs, production, power, etc.
   b. The meaning of pollution.
   c. The needs of growing suburbs.
   d. The overall need for low priced energy.
   e. The need of a clean environment.

2. Act as council president (moderator) for a role playing lesson where students have been assigned to represent various interest groups. Allow three minutes per presentation.

3. Have the remaining students act as the council and ask questions and vote on:

   a. Whether to allow the atomic power plant.
   b. Which method should be used to eliminate the heat from the plant.

SUMMARY

1. "Ask each student to write his or her answers and the reasons for them."

2. "Which argument was the most convincing?" "Why?"

3. "What did the other groups do to lose your vote?"

## Lesson 10: IS THERE A FUTURE FOR NUCLEAR POWER PLANTS?

AIM: "Why has the construction of nuclear power plants almost completely ceased?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe the changing nature of our energy sources.
- discuss the pros and cons of the use of nuclear energy.

MATERIALS: Newspaper stories and magazine articles for class distribution.

MOTIVATION: "In 1970, government officials in the United States estimated that 1200 large nuclear reactors would be built in this country before the year 2000. In 1978 officials estimated that fewer than 300 reactors would be built by the year 2000. What might have happened during the 8-year period?" Outline the responses on the chalkboard.

DEVELOPMENT

1. Either spend a class period discussing the construction of nuclear plants or distribute the attached article to the class to read. The teacher should find suitable material, depending on the ability of the class. Included in the set should be the article "NRC to Hear Final Testimony, Plans Long-Range Study."

2. The class may be divided as follows: A four-person panel that will serve as the Nuclear Regulatory Commission; the remainder of the class divided into two groups, a pro-nuclear group, and an anti-nuclear group. Each will present its case to the commission.

3. The teacher can act as a facilitator. If difficulty appears in the discussion, the teacher may ask:

    a. "If no nuclear plants are built, how will areas that have planned for them be supplied with electricity?"

    b. "If all plants are shut down, what sources of energy will replace them?"

    c. "What areas of the USA have the greatest concentration of nuclear power plants?" "Why?"

    d. "Why is nuclear power growing?" "Is nuclear power growing too rapidly or not rapidly enough?" "Explain."

    e. "What could be the results if nuclear power supplies a greater portion of our energy needs?"

SUMMARY

. Have the students who acted as the Nuclear Regulatory Commission reach a decision and give reasons; or, as one variation to the lesson, have the class debate about the advantages and disadvantages of using nuclear energy.

* **NOTE TO TEACHER:** It is important that the teacher not take sides in this debate.

NRC TO HEAR FINAL TESTIMONY

# NRC To Hear Final Testimony, Plans Long-Range Study

## Recommendation to Come on Whether Plants Under Construction Will Be Halted

The Nuclear Regulatory Commission will hear final testimony in its hearings on whether or not to permit the construction of new nuclear power plants.

The NRC has been listening to nuclear power experts to determine if the risk to civilian health and safety warrants a halt to new plant construction.

Recent incidents and shutdowns of nuclear power facilities prompted the NRC to study the safety of all nuclear plants.

Antinuclear groups are concerned about meltdowns and nuclear fallout that would endanger the lives of thousands of people in communities surrounding the plants. Antinuclear groups are also concerned about nuclear waste disposal. There have been claims of slight radioactive contamination of drinking water and emissions into the atmosphere near waste disposal sites.

The nuclear industry stands on its record of no deaths or threats to life from any plant accident. Pronuclear experts have also stated that all radiation emissions from plants, planned or accidental, have been far below strict federal standards for safety. European countries have demonstrated successful nuclear waste disposal techniques, pronuclear scientists have explained. The industry feels that nuclear power is extremely necessary if the U.S. is to be energy self-sufficient.

Some angry antinuclear forces are questioning whether there are *any* safe levels of radiation.

The NRC must decide today whether to prohibit the construction of new plants, shut down all current plants as well, or allow their industry to continue as is.

Representatives from the nuclear industry and antinuclear groups will argue their case before the NRC board today. The board is then expected to make one of the following decisions:

a) If the NRC agrees with antinuclear groups and decides to shut down all current plants and prohibit construction of any future ones, the U.S. will have 0 units of nuclear power available for energy use.

b) If the NRC permits only plants that have excellent safety records to remain in operation, the U.S. will have 10 units of nuclear power.

c) If current plants are allowed to continue operating, but future plants are prohibited, the U.S. will have 20 units of nuclear power.

d) If the NRC decides in favor of the nuclear industry after reviewing its record and approves construction of new plants and continued operation of current ones, the U.S. will have 30 units of nuclear power for its energy needs.

News Bulletin, Institute of Lifelong Learning (Long Beach, Ca., 1980).

## Lesson 11: WHAT FACTORS INFLUENCE DECISION MAKING?

AIM: "How did you determine your position on nuclear power plants?"

PERFORMANCE OBJECTIVES: The students will be able to:

- analyze the factors that caused them to make their decision on the power plant.
- evaluate data from different points of view.

MATERIALS: None.

MOTIVATION: "How do you decide who should be your friend?"

DEVELOPMENT

1. Help the students analyze their decisions during a class discussion. Use the following questions.
    a. "Does your perception remain the same regardless of which pressure group you're involved with?"
    b. "How reliable are the data we use to make decisions?"
    c. "Were your decisions based on quantitive data, qualitative data or emotions?"
    d. "What inferences were drawn from your observations of the data?"
    e. "What goes into making a decision?"

2. Conduct a student discussion using the following questions as a guide.

    "Would your decision have been different if:

    a. you worked for the electric company?
    b. you had all your money in electric company stock?
    c. you were a business person using or needing large amounts of cheap electricity?
    d. you rented boats on the lake?
    e. you ran a summer resort on the lake?
    f. you were a home owner using the lake as your source of drinking water?"

SUMMARY

Ask the students to write a paragraph explaining the following statement:

> Environmental solutions must involve social, political, economic, and ecological components.

# Lesson 12: HOW CAN SCIENTISTS HELP INSURE OUR ENERGY FUTURE?

AIM: "How does a mirror help us harness energy?"

PERFORMANCE OBJECTIVES: The students will be able to:

- describe the potential roles of scientists in the effort to conserve energy.
- describe various techniques available to expand our supply of energy including use of renewable resources.

MATERIALS: Parabolic mirror.

MOTIVATION: Display a parabolic mirror. Ask: "How can this help us harness the sun's energy?"

DEVELOPMENT

1. Relate the role of the physicist to new techniques using solar energy.
   a. parabolic mirror ovens in tropical climates
   b. solar panels to provide hot water for homes
   c. solar panels for electricity
2. Ask: "How does the eruption of Mt. St. Helens suggest another alternative energy source available to man?" (geothermal energy)
3. Relate the role of the chemist to the following processes:
   a. liquifying abundant coal deposits to produce fuels
   b. converting oil shale into usable fuel
4. Discuss how geologists have reclaimed oil trapped in old wells by using superheated water to flush out trapped oil.
5. Relate the role of the biologist to the process of bioconversion (crops into fuel).
   a. Kelp and water hyacinth are converted into methane in garbage landfills and sewage treatment plants.
   b. Unused and inedible plant parts are converted into alcohol for fuel. Examples:

      Brazil's use of sugar cane plant to produce alcohol.
      Gasohol (90% gasoline, 10% alcohol).

SUMMARY

- "Write a paragraph summarizing the roles of scientists in developing renewable sources of energy."

## FOR FURTHER THOUGHT

1. "Why will our ultimate source of energy probably still be the sun?"
2. "Suggest a joint venture that scientists might undertake to help solve the energy problem. Put your suggestions in the form of a letter addressed to the president of one of the scientific organizations."

# Lesson 13: WHAT KINDS OF CAREERS ARE IN THE FIELD OF ENERGY?

AIM: "What are some energy-related careers?"

PERFORMANCE OBJECTIVES: The students will be able to:

. define the various fields of energy and how they are related.
. list several occupations in each of the fields.

MATERIALS: Handout, "Careers in the Field of Energy."

MOTIVATION: "How many careers can you name in the field of energy?"

DEVELOPMENT

1. Discuss the fact that the energy field consists of oil and gas industries, a coal industry, an electric power generating industry, a nuclear energy industry, and a solar energy industry. There are also several minor branches of this field built around geothermal energy resources, wind energy, and tidal energy.

   People who are looking ahead to careers in the field of energy can choose not only the branch of the industry that appeals to them but also from among several kinds of work within each branch. The choices depend upon an individual's interests and the number of years he or she is willing to invest in education.

   In addition to providing highly technical jobs, each energy industry also provides jobs and careers related to sales and distribution. For instance, people are needed to pump gas, to send out electric bills, and to program the transmission of electric power. In short, once a person decides to develop an awareness of the vital role of energy in our society and scrapes up the courage needed to deal with something as mysterious as energy, a wide array of job and career opportunities opens up.

2. Distribute handout, "Careers in the Field of Energy." Discuss the three educational levels of occupations available in each industry.

SUMMARY

1. "Name three emerging careers in the field of energy."

2. "Select a field of energy. Research the duties of one of the occupations in which you are interested."

FOR FURTHER THOUGHT

1. "Choose one of the careers listed on the student sheet. What college courses would you have to take if you were to decide on this career?" "What type of college should you attend?"

2. "What type of industry or institution could you visit to explore the career possibilities in this field?" "What questions would you ask?"

# STUDENT SHEET

## Careers in the Field of Energy

| Branch | 4-year degree grad. school | 2-year degree | High School degree |
|---|---|---|---|
| OIL | engineers<br>scientists<br>chemists<br>geologists<br>geophysicists | engineering technicians<br>engineering technologists<br>lab technicians | oil well drillers<br>welders<br>iron workers<br>cooks<br>messengers, etc. |
| COAL | mining engineers<br>chemists<br>analytical chemists<br>environmental engineers<br>mine safety inspectors<br>coal gasification engineers | engineering technicians<br>engineering technologists<br>lab technicians | miners<br>truck drivers<br>laborers |
| SOLAR | electrical architects<br>design architects<br>environmental engineers<br>civil engineers | architectural technicians<br>engineering technologists | sheet metal workers<br>plumbers<br>electricians<br>iron workers<br>welders |
| NUCLEAR | nuclear engineers<br>electrical engineers<br>radiation chemists<br>nuclear physicists<br>health physicists<br>mathematicians<br>radiological physicists<br>radiological chemists | radiator monitors<br>nuclear reactor operators<br>radiographers<br>radioisotope production operators | pipefitters<br>electricians<br>carpenters<br>welders |
| ELECTRIC POWER | electrical engineers<br>power engineers<br>mechanical engineers<br>design engineers<br>environmental engineers<br>nuclear engineers<br>nuclear physicists<br>environmental scientists<br>civil engineers | engineering technologists<br>engineering technicians<br>lab technicians<br>environmental workers | boilermakers<br>sheet metal workers<br>electricians<br>welders |

# Theme II — Questions for Review

Unit 6. Insuring our Energy Future

NAME ______________________ CLASS __________ DATE ______________

1. Which of the following is not an energy source traceable to the sun?
   a. wood
   b. coal
   c. oil
   d. nuclear power

2. The only one of the following that is not a fossil fuel is:
   a. coal
   b. oil
   c. natural gas
   d. uranium

3. A good way to conserve energy is to:
   a. turn thermostats up in winter
   b. insulate your home
   c. turn on more lights
   d. raise shades on the sunny side of your house during the summer

4. Which of the following is an example of a nonrenewable energy source?
   a. fossil fuels
   b. nuclear fuels
   c. solar radiation energy
   d. geothermal energy

5. Which of the following is a source of nuclear energy?
   a. uranium
   b. oil
   c. nitrogen
   d. oxygen

6. The most widely used energy source is:
   a. nuclear
   b. solar
   c. fossil fuel
   d. electricity

7. Most of our oil is used:
   a. to heat homes
   b. for transportation of people and goods
   c. to operate electric generating plants
   d. to run industrial plants

8. Trees are a good example of:
   a. fossil fuels
   b. renewable resources
   c. minerals
   d. nonrenewable resources

NAME ________________________________

Matching

| | | Column A | Column B |
|---|---|---|---|
| 9. | _____ | Energy source that can be reproduced in a few years | a. renewable energy source |
| 10. | _____ | Produced from heat within the earth | b. hydroelectric power |
| 11. | _____ | Made artificially from chemical changes of coal | c. geothermal energy |
| 12. | _____ | Energy source that can be used up | d. synthetic fuel |
| 13. | _____ | Uses the energy of falling water | e. nonrenewable energy source |

True or False

14. _____ Coal energy may become an alternate energy source to replace fossil fuels.

15. _____ Minerals and fossil fuels are nonrenewable resources.

16. _____ A future source of oil may be found in shale.

17. _____ Anthracite coal requires less heat and pressure to be formed than bituminous coal.

18. _____ Fossils are found mainly in metamorphic rocks.

Explain

19. What are three different types of fossil fuels? How do they differ?

20. Why does the dwindling supply of nonrenewable natural resources pose a difficult problem for conservationists?

21. What are some of the problems that may occur if coal is used as a major source of energy to generate electricity?

22. What is meant by bioconversion?

23. Suppose we began an active conservation program today. List some ways in which such a program would affect the habits of governments, business, industry, and individuals. Would a conservation program solve our energy crisis? Why or why not?

# FINAL EXAMINATION
# GENERAL SCIENCE (THEMES I AND II)

NAME ______________________________ CLASS __________ DATE ______________

1. When a scientist makes an educated guess to answer a problem, she is forming:
    a. a superstition
    b. an observation
    c. an experiment
    d. a hypothesis

2. The essential part of a scientific experiment that provides a comparison with the experimental results is called the
    a. problem
    b. observation
    c. hypothesis
    d. control

3. The control group and the experimental group should be:
    a. exactly the same in every way
    b. exactly the same in every way except one
    c. different in at least two ways
    d. completely different

4. A hypothesis is:
    a. tested through experimentation
    b. assumed to be true
    c. accepted to be scientific law
    d. a collection of false statements

5. The scientific method is a procedure to:
    a. formulate a hypothesis
    b. make observations
    c. solve problems and answer questions
    d. determine the control in a scientific experiment

6. A system of measurement must contain all of the following except:
    a. any unit of measurement which is easily reproduced
    b. specific measuring instruments
    c. an agreement by a large number of people to use the system
    d. use of specific units for length, mass, and time

7. The volume of one gram of water is:
    a. one liter
    b. one milliliter
    c. one centimeter
    d. one decimeter

NAME ______________________________________________

8. The basic unit of length measurement used by the metric system is the:
    - a. meter
    - b. liter
    - c. gram
    - d. calorie

9. To measure the size of this examination paper you would use:
    - a. meters
    - b. centimeters
    - c. millimeters
    - d. any of the above

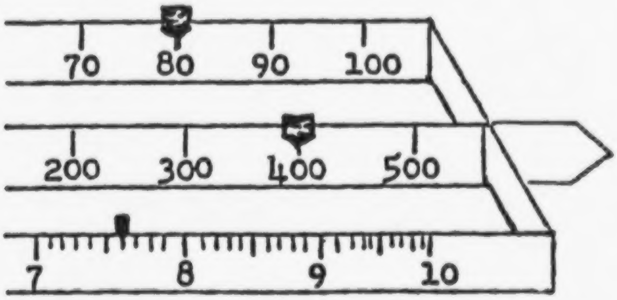
10. Temperature is measured in a unit called a:
    - a. gram
    - b. calorie
    - c. degree
    - d. British Thermal Unit

11. Gram is to kilogram as meter is to:
    - a. liter
    - b. millimeter
    - c. centimeter
    - d. kilometer

12. The silvery liquid inside a thermometer is:
    - a. alcohol
    - b. mercury
    - c. silver nitrate
    - d. molten aluminum

13. Which of the following symbols would be found on a triple beam balance?
    - a. g
    - b. cm
    - c. ml
    - d. 0°C

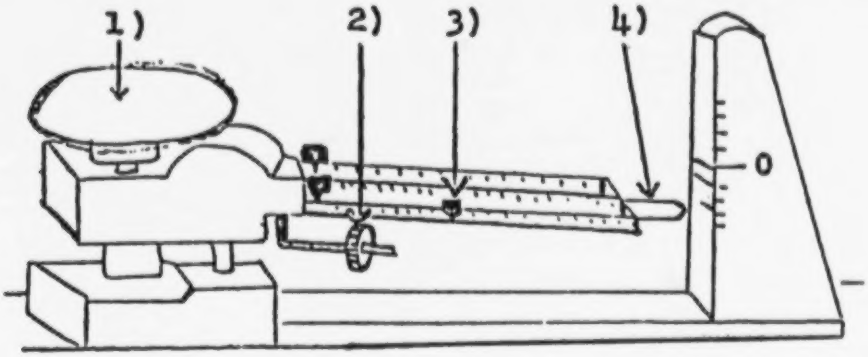
14.



This diagram is part of a triple beam balance. What is the mass of the object being massed as shown by the riders on the three beams?
    - a. 487.6 grams
    - b. 4.876 grams
    - c. 48.76 grams
    - d. 4,876 grams

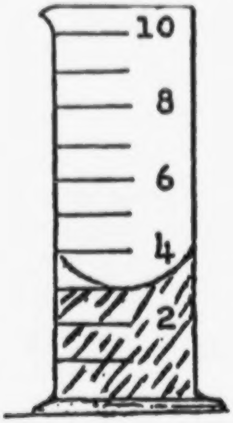
NAME ______________________________________

15. This is a diagram of a triple beam balance as it might have been given to you. Which is the first part you should move or adjust to get this balance ready for use?



- a. 1
- b. 2
- c. 3
- d. 4

16. The water shown in the graduated cylinder curves upwards at the edges where the water comes in contact with the glass of the cylinder. What is this upward curving of the water called?

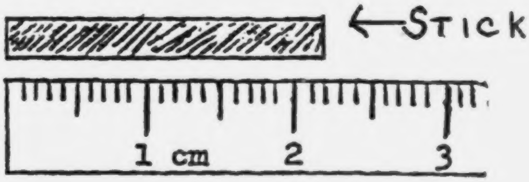


- a. hibiscus
- b. meniscus
- c. arbiscus
- d. polythemiscus

17. How much water is there in the graduated cylinder shown in question number 16?
- a. 2.0 ml
- b. 2.5 ml
- c. 3.0 ml
- d. 4.0 ml

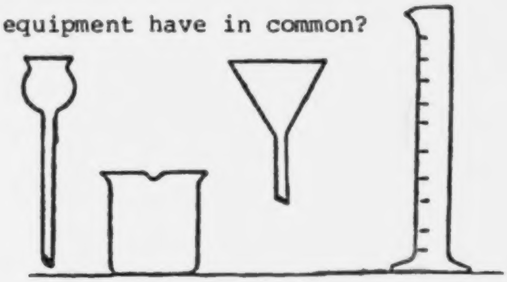
NAME ________________________________________

18. What is the length of the stick shown in this diagram?



a. 2.2 millimeters
b. 22 centimeters
c. 2.2 centimeters
d. 2.2 meters

19. What do all these pieces of equipment have in common?



a. These pieces of glassware are always made of heat resistant material.
b. The equipment shown is used to pour liquids into other containers.
c. All these items are used to measure exact amounts of liquids.
d. These pieces of glassware are used for the storage of liquids.

20. As a rock falls off a cliff:
a. potential energy changes into kinetic energy
b. kinetic energy changes into potential energy
c. total energy decreases
d. total energy increases

21. According to the law of conservation of energy, energy:
a. can be created
b. can be destroyed
c. can always be stored
d. can be transformed

22. A moving ball strikes an object at rest and causes the object to move. This shows that:
a. kinetic energy is destroyed
b. kinetic energy is created
c. potential energy is destroyed
d. kinetic energy can be transferred

NAME ________________________________________

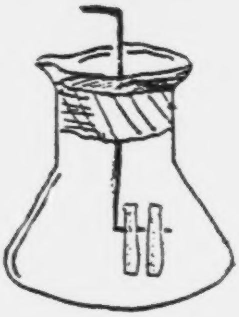
23. Lightning is dangerous because it can:
    a. cause fire
    b. split a tree and knock it over
    c. electrocute a living thing
    d. all of these

24. A discharge of electricity from negatively charged clouds to positively charged clouds is called:
    a. hail
    b. lightning
    c. thunder
    d. snow

25. A device that automatically opens a circuit in case of overheating is a(n):
    a. switch
    b. resistor
    c. dry cell
    d. fuse

26. Current follows a complete closed path in a(n):
    a. wire
    b. insulator
    c. fuse
    d. circuit

27. The apparatus shown below is called a(n):
    a. radiometer
    b. circuit
    c. Wimshurst machine
    d. electroscope



28. A device used to increase or decrease voltage is a(n):
    a. electroscope
    b. generator
    c. transformer
    d. electromagnet

29. The kilowatt measures:
    a. energy
    b. power
    c. current
    d. resistance

NAME ____________________________________________

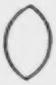
30. Conduction of heat occurs mainly in:
    a. solids
    b. liquids
    c. gases
    d. all of these

31. The transfer of heat energy in a circulatory gas is known as:
    a. conduction
    b. convection
    c. radiation
    d. circulation

32. An increase in temperature can cause changes in:
    a. length
    b. volume
    c. molecular motion
    d. all of these

33. The rising column of smoke from a smokestack is mainly due to:
    a. conduction
    b. convection
    c. radiation
    d. induction

34. A steel building is taller in summer than in winter because:
    a. the building has more particles in the summer
    b. the spaces between its particles have become smaller
    c. the spaces between its particles have become greater
    d. its particles move more slowly in summer

35. A lens that has this shape  when viewed from the side is called:
    a. convex
    b. concave
    c. plano
    d. reflecting

36. When a ruler is placed in water at an angle, besides appearing bent, the ruler appears to be:
    a. curved
    b. smaller
    c. magnified
    d. heavier

37. In the human eye, images are usually formed on the:
    a. pupil
    b. lens
    c. cornea
    d. retina

NAME ________________________________________

38. Mirrors affect light by:
    a. changing its speed
    b. refracting it
    c. reflecting it
    d. changing its color

39. To test to see if a lens can produce a real image, we would:
    a. try to focus the image on a screen
    b. turn the lens upside down
    c. look into the lens
    d. turn the object upside down

40. The bending of light as it passes from one transparent medium to another is called:
    a. refraction
    b. reflection
    c. polarization
    d. an optical illusion

41. Which piece of optical equipment is used to produce a visible light spectrum from white light?
    a. concave lens
    b. prism
    c. color filter
    d. rectangular solid

42. The sequence of colors that appear in a spectrum when white light is dispersed is:
    a. yellow, orange, red, green, blue, indigo, violet
    b. orange, green, yellow, red, blue, indigo, violet
    c. blue, green, indigo, violet, red, orange, yellow
    d. red, orange, yellow, green, blue, indigo, violet

43. In an atom the electrons are found:
    a. in shells around the nucleus
    b. everywhere in the atom
    c. in shells within the nucleus
    d. in clouds within the nucleus

44. An atom has a stable electron arrangement if it:
    a. requires very little energy to remove an electron
    b. has completed electron shells
    c. is chemically active
    d. all of the above

45. The smallest particle of an element that retains the properties of the element is:
    a. a photon
    b. an atom
    c. an electron
    d. a proton

NAME ______________________________

46. An atom is neutral when it has the same number of electrons as:
    a. energy levels
    b. neutrons
    c. protons
    d. isotopes

47. When an element emits particles and changes to a different element, it is said to undergo:
    a. physical change
    b. chemical change
    c. radioactive decay
    d. metamorphosis

48. Gamma rays are most similar to:
    a. radio waves
    b. infrared waves
    c. X-rays
    d. visible light rays

49. A device that is used to detect radioactive particles is:
    a. an electroscope
    b. a cyclotron
    c. a Geiger counter
    d. a transformer

50. Radioactive isotopes that are used to track a chemical pathway are called:
    a. ions
    b. tracers
    c. atomic cocktails
    d. radiators

# FINAL EXAMINATION

## ANSWER KEY

1. d
2. d
3. b
4. a
5. c
6. b
7. b
8. a
9. a
10. c
11. d
12. b
13. a
14. a
15. c
16. b
17. c
18. c
19. b
20. a
21. d
22. d
23. d
24. b
25. d
26. d
27. d
28. c
29. b
30. a
31. b
32. d
33. b
34. c
35. a
36. c
37. d
38. c
39. a
40. a
41. b
42. d
43. a
44. b
45. b
46. c
47. c
48. c
49. c
50. b

## GOVERNMENT AGENCIES FROM WHICH FREE INFORMATION MAY BE OBTAINED

### New York City Agencies

Bureau of Water Register
Municipal Building
New York, NY 10007

Bureau of Water Supply
1250 Broadway
New York, NY 10001
966-7500

Bureau of Water Pollution Control
20 Worth Street
New York, NY 10013

Department of Environmental Protection
2358 Municipal Building
New York, NY 10007
566-4124
Citizens' Complaints (966-7500)

Environmental Control Board
333 W. 34th Street
New York, NY 10001
971-3600

Bureau of Sewers
40 Worth Street
New York, NY 10013

### New York State Agencies

New York State Energy Research and Development Authority
Agency Building 2
Rockefeler Plaza
Albany NY 12223
(518) 465-6251

Department of Environmental Conservation
2 World Trade Center
New York, NY 10047
488-2788

### Federal Agencies

Environmental Protection Agency
401 M Street S.W.
Washington D.C. 20460
(202) 755-2670

NY Area
26 Federal Plaza
New York, NY 10278
264-2525

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